Cisco Systems

Cisco Networking Academy Program

CCNA 1: Networking Basics v 2.1.4

Student Lab Manual

Lab 1.1.1 PC Hardware

Estimated time: 60 min.

Objectives:

This lab will focus on your ability to accomplish the following tasks:

- Connect peripheral components (monitor, keyboard, and so on) to the main PC system unit
- Name the typical PC components
- Identify major internal PC components and connections
- Document the configuration of a functioning PC
- Boot a system to Windows operating system (Windows 95, 98, NT or 2000)

Use the Control Panel, System icon utility to gather information about the PC configuration.

Background:

This lab will help you become familiar with the basic peripheral components of a PC computer system and their connections including network attachment. You will also examine the internal PC configuration and identify major components. You will observe the boot process for the Windows operating system and use the Control panel to find out information about the PC. Knowing the components of a PC is valuable when troubleshooting and is important to your success in the networking field. For some of you, this lab will be a review.

Tools / Preparation:

This is a hands-on lab. Before you begin, the instructor or lab assistant should have a typical desktop Pentium-based PC available with all peripherals such as keyboard, monitor, mouse, speakers or head phones, a network interface card (NIC) and network cable. The system unit cover should be removed or tools provided to remove it. You may work individually or in teams. In addition, the instructor needs to identify the location of the A+ or PC hardware training materials for the students. The following resources will be required:

- PC with Monitor, keyboard, mouse, and power cords
- Windows operating system (Win 95, 98, NT, or 2000) installed on PC
- Sound card and speakers or head phones
- Network Interface Card and Cat 5 patch cable
- A+ or PC hardware training materials

Notes:

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Step 1 - Examine the computer for internal and external components.

Task: Examine the computer and peripheral components both front and back.
Explanation: The components and configuration of the PC you are working with may vary from the sample answers below.

1. What is the manufacturer and model number of this computer?

Manufacturer	
Model Number	

2. Remove the PC system unit cover. List at least 8 major internal components inside the system unit (Use the procedure in step 3 to find the CPU and amount of RAM).

Component Name	**Manufacturer / Description / Characteristics**

3. What are the major external components of the PC including the peripherals?

Component Name	**Manufacturer / Description / Characteristics**

Step 2 - Observe the boot process.

Task: Assemble the PC components and attach all peripherals and boot the PC. Observe the boot process.
Explanation: The computer should boot to the Windows operating system. If the computer does not boot contact the lab assistant.

1. Observe the boot process.
    a. Did the Windows operating system boot OK?

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    b. Could you see how much memory there was as the system was booting?

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Step 3 - General system information.

Task: Click the Start button and select Settings and Control Panel. Click the System Icon and then the General tab.
Explanation: You are viewing information about the computer using the operating system.

1. What is the Central Processing Unit?

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2. How much RAM is installed?

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Lab 1.1.4 Install a NIC

Objectives:

Demonstrate proper installation of a NIC in a PC.

Background:

A network interface card allows a computer to connect to a network and share files or resources with other computers. Network cards are relatively easy to install, as long as simple guidelines are followed.

Tools / Preparation:

- a computer system running at least Windows 95
- empty PCI or ISA expansion slot
- PCI or ISA Network card (Ethernet adapter) depending on which slot is available in the computer
- network card driver disk and/or the appropriate Windows CD
- network cable
- toolkit set
- static mat and wrist strap

Worksheet

1. Turn off your computer and unplug the power cable. Use a static mat and wrist strap to ground yourself.
2. Remove the cover and then the dust plate from computer case for the empty PCI or ISA expansion slot in which you plan to install the NIC.
3. Remove the network card from the anti-static bag. Handle the top corners of the network card with both hands. Align the tabs of the network card with the slot and gently rock the card front to rear to insert it into the expansion slot. Finally, secure the card to the case with a screw.
4. Replace the cover of the computer case and then restart the computer. The Windows setup hardware detection will automatically determine the adapter driver for your network card. Windows may ask you to supply your computer name and workgroup name. Select a computer name for your PC and use a specific workgroup name provided by your lab instructor.
5. Double-click on the Network Neighborhood icon or my Network Places icon (depending on the operating system) on the desktop. If you find other computer names displayed in the window, the network card is working properly. If you do not find other computer names then Windows may have installed an incorrect driver for your network card. If so, you will need to do the following steps to add an adapter driver:
    a. Click the Start button, select Settings, then select Control Panel.
    b. Double-click the Network icon or Network and Dialup Connections (depending on the operating system). A network dialog box will appear.
    c. Click on the Add button or Make New Connection (depending on the operating system). Select adapter and click on the Add button once again.
    d. Click on the Have Disk button. Insert the network card driver disk into the floppy drive. Click OK. The Windows setup will install the driver.
    e. Windows may ask you to reboot your system. After you restart the computer, follow the instructions in the beginning of this exercise to check whether your network card is working properly.

Reflection

Write in your journal the steps that you used to install a network card. Also write what precautions you took and why they were important.

Notes:

Lab 1.2.1.1 TCP/IP Network Settings

Estimated time: 45 min.

Objectives:

This lab will focus on your ability to accomplish the following tasks:

- Use the Windows Network Icon in the Control Panel to determine current network settings
- Use the WINIPCFG.EXE utility (with Windows 95 or 98) or IPCONFIG.EXE (with Windows 2000 or NT) to determine network settings
- Identify the type of client software being used and record related settings
- Determine the Computer name and Domain name
- Determine the NIC manufacturer and driver
- Identify what network (Layer 3) protocols are bound to the NIC (in use)
- Determine the Internet Protocol (IP) Layer 3 address
- Determine the subnet mask and IP address of the default gateway (router)
- Determine whether Domain Name System (DNS), Dynamic Host Configuration Protocol (DHCP) and Windows Internet Name Service (WINS) are being used and the IP addresses of the servers providing these services
- Determine the Media Access Control (MAC) or hardware address of the workstation NIC
- Use the Windows System Device Manager to verify that the NIC is working properly
- Document all findings in this lab

Background:

This lab will help you become familiar with the network settings required to connect your PC to a local area network and to gain access to the Internet (World Wide Web - WWW) and Intranet (internal local web servers). The purpose of this lab is to discover what the workstation network settings are and how they are used. You will review Network Interface Card (NIC) configuration, drivers, and TCP/IP protocol settings for a typical Windows client workstation in a server-based Ethernet network. This information is very valuable any time you have a problem logging onto a network or when you must set up a new workstation.

Tools / Preparation:

This is a hands-on lab. Before you begin, the teacher or lab assistant will have a typical desktop Pentium-based (or comparable) PC available. The desktop policies must be set to allow access to the Network icon in Control Panel and either the Run Command or the DOS Command Prompt in order to run the WINIPCFG.EXE or IPCONFIG.EXE (depending on the operating system) utility. The PC should be a classroom/lab computer configured to access the web-based Cisco curriculum and assessment system. You may work individually or in teams. The following resources will be required:

- PC workstation with monitor, keyboard, mouse, and power cords

- Windows operating system (Win 95, 98, NT, or 2000) installed on PC
- NIC installed and Cat 5 patch cable with connection to the Internet
- Browser software installed (Netscape Navigator 4.6.1 or higher or Internet Explorer 5.1 or higher)
- Java, JavaScript, and Style Sheets (must be enabled in your browser's preference settings)
- Flash plug-in (Curriculum version 2.1 only)

Notes:

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Step 1 - Determine the network settings for your workstation.

Task: Boot (start) the PC, log in to the network and use the following procedures to determine the network settings for your workstation.
Explanation: The primary tools you will use for gathering this information are:

1. the Network icon or Network and Dialup Connection icon in Control Panel
2. the WINIPCFG.EXE utility (Windows 95 or 98) or IPCONFIG.EXE (Windows NT or 2000)
3. the System icon in Control Panel

You will use these tools to verify your network settings and that the NIC is functioning properly. The following procedures focus primarily on a Windows NT server-based network. Answers will vary depending on the PC you are using and the network you are on.

Step 2 - Use Control Panel / Network to determine the Workstation Computer name, NT Domain name, Network Client, the network Layer 3 protocols in use, and information about the NIC.

Task: Click on Start, select Settings and then Control Panel. Double click the Network icon. Click the Identification Tab at the top of the window to find the Computer name and the Domain name (Windows NT). Click the Configuration Tab and note what networking components are installed.
Explanation: The Network Client has an icon that looks like a computer, the NIC icon looks like a NIC and the Protocols have an icon that looks like a network cable connection. There may be more than one of each of these.

Record your findings in the table below.

Component (NetBIOS) Name	
NT Domain Name	
Network Client Type	
NIC installed (driver name)	

1st Protocol installed	
2nd Protocol installed	
Other network components	
Other network components	

Step 3 - Use Control Panel / Network to check the TCP/IP related settings such IP address information, DHCP and DNS.

Task: Click on the TCP/IP protocol while on the Network Configuration Tab and then click Properties.
Explanation: Click on the Tab indicated in the table and record your findings below.

1. Record your findings in the table below.

TAB	Type of Information	Findings
IP Addr.	How does the workstation get its IP Address	
IP Addr.	Workstation IP Address	
IP Addr.	Workstation Subnet Mask	
Gateway	Default Gateway	
DNS Cfg.	Is DNS enabled?	
DNS Cfg.	DNS Server IP Address	
WINS Cfg.	Is WINS enabled?	
WINS Cfg.	WINS Server IP Address	

Step 4 - Using WINIPCFG.EXE or IPCONFIG.EXE utility

Task: You can run WINIPCFG.EXE from the Start / Run command or from the DOS command prompt. IPCONFIG.EXE must be run from the DOS prompt. To run it from the Start menu Click on Start and Run, then type in WINIPCFG in the window. To run it from the DOS prompt, click Start, Programs, MS DOS Prompt and then type WINIPCFG or IPCONFIG at the command line. If you enter WINIPCFG /ALL or IPCONFIG /ALL (be sure to put a space between WINIPCFG or IPCONFIG and /ALL) you will get much more information.
Explanation: The WINIPCFG.EXE or IPCONFIG.EXE utility can also be used to check TCP/IP related settings as well as the MAC address of the NIC installed (also called the hardware address). When the TCP/IP protocol is installed on Windows 95 or 98, the graphical WINIPCFG.EXE utility is included with it. Windows NT and 2000 use a different utility, IPCONFIG.EXE, to give similar results. However, these results will not be presented in a graphical format. If your workstation obtains its IP address automatically (a DHCP client) you must use one of these utilities to determine its IP address and subnet mask. Be sure to select the proper NIC or Ethernet adapter (this will be in a pull-down box).

1. Record your findings in the table below.

Workstation IP Address	

Workstation Subnet Mask	
Workstation MAC Address	
Default Gateway (Router)	
DHCP Server	
DNS Server IP Address	
WINS Server IP Address	

Step 5 - Use Control Panel / System / Device Manager to verify that the NIC and drivers are functioning properly.

Task: Click on Start, select Settings and then Control Panel. Double-click the System icon, click the Device Manager Tab at the top of the window and then click the plus sign on the Network Adapter icon. Select the desired adapter and click properties. Click the General Tab to see the Adapter Manufacturer and check the status. Click on the Driver Tab to see the version of the driver and files being used.
Explanation: You can also find the operating system version, the CPU type and the amount of RAM installed.

1. Record you findings in the table below.

Network Adapter (NIC) Manufacturer	
Is the Network Adapter Working properly?	
Date of the Driver	
List one of the Driver Files	

Lab 1.2.1.2 PC Software

Estimated time: 30 min.

Objectives:

This Lab will focus on your ability to accomplish the following tasks:

- Determine the PC operating system and version number
- Identify the manufacturer and version number of the BIOS the computer is running
- Learn how to access the CMOS settings for the computer
- Check browser software setup including version and necessary plug-ins

Background:

This lab will help you become familiar with the PC Operating System, Basic Input Output System (BIOS) and Application software configuration. You will verify that the PC is configured properly to run the Cisco Online Curriculum and practice exams, which are multimedia based. This includes the Operating system, Video settings, Browser and Plug-ins required. For some of you, this lab will be a review.

Tools / Preparation:

This is a hands-on lab. Before you begin, the teacher or lab assistant will have a typical desktop Pentium-based (or comparable) PC available with the following software installed. The PC should be a classroom computer configured to access the web-based Cisco curriculum and assessment system. You may work individually or in teams. The following resources will be required:

- PC workstation with monitor, keyboard, mouse, and power cords
- Windows operating system (Win 95, 98, NT, or 2000) installed on PC
- NIC installed and Cat 5 patch cable with connection to the Internet
- Browser software installed (Netscape Navigator 4.6.1 or higher or Internet Explorer 5.1 or higher
- Java, JavaScript, and Style Sheets (must be enabled in your browser's preference settings)
- Flash plug-in

Notes:

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Step 1 - PC Software Overview

Task: Before booting the PC, determine the manufacturer and model number.
Explanation: Boot (start) the PC and use the following procedures to determine

the BIOS. Answers will vary depending on the PC. You can "cold boot" the PC by turning it off and on again. You can "warm boot" it by pressing the Ctrl and the Alt keys at the same time and then press the Delete key while holding them down. Be sure to shut down Windows properly before rebooting by clicking Start and Shutdown.

1. What is the PC Manufacturer & model?

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Step 2 - Operating system

Task: Determine the operating system and version.
Explanation: You can check the operating system by watching the screen as the computer boots, or by clicking Start, then Help after it has finished booting. To verify the exact version number, click Start, Settings, Control Panel then double-click the System icon. This will also show the manufacturer, model, CPU and amount of RAM in the PC.

1. What operating system (OS) and version is the computer running?

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Step 3 - CMOS setup

Task: Determine the keys to press to enter CMOS setup. Determine the BIOS manufacturer and version number.
Explanation: While booting the system, watch the screen to see what keystroke(s) are required to enter the CMOS setup mode. CMOS setup can be used to change settings such as the boot sequence (floppy, CD or hard disk) and power saver options. As the system is booting you should also see who makes the Basic Input Output System (BIOS) and what version it is.

1. How would you access the CMOS setup to change settings?

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Step 4 - Verify browser software and plug-ins.

Task: Determine the browser software and version and check for the plug-ins required to view the Cisco online computer-based curriculum.
Explanation: Start the Browser (Netscape or Internet Explorer) on the computer and determine the following information. Start one of the lessons from the Cisco online computer-based curriculum, run a movie clip, and take a sample quiz. Flash (from Macromedia) is required to run the sample quizzes.

1. What is the browser software and version?

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2. Is the Flash plug-in on this computer?

3. Does the sound work when playing the videos?

Step 5 - Verify your video settings

Task: Click on Start, Settings, Control Panel and then double click on the Display icon. Click the Settings tab.
Explanation: The Display settings allow you to confirm that you have at least 800 x 600 resolution with 256 colors.

1. Record the settings on your computer below:

Screen area (resolution)	
Color	

Lab 1.2.2 Web Browser Literacy

Estimated time: 20 min.

Objectives:

- Learn how to use a web browser to access Internet sites
- Become familiar with the concept of a URL
- Use a search engine to locate information on the Internet
- Access selected websites to learn the definitions of networking terms
- Use hyperlinks to jump from the current website to other websites

Background:

A web browser is a very powerful tool that many people use everyday to surf around different sites (cyber places) on the World Wide Web. With a web browser you can find anything from airline flight information to the directions on how to get to a specific address. A browser is a client application program or software that is loaded on the PC to gain access to the Internet and local web pages.

The name of a website such as **www.cisco.com** is also referred to as a Universal Resource Locator (URL). This URL points to the World Wide Web server (www) in the Cisco domain (cisco) under the Commercial domain (com). The www also refers to an HTTP or Hypertext Transfer Protocol server. You may also type in a slash after the website name and then name of a web page to get to a specific location on a website. When you type in the URL or name of a website, your browser makes a request of a Domain Name Server (DNS) in order to convert the URL to an IP address. The IP address is how the server (www.cisco.com) is actually contacted.

Web Browsers can provide access to a number of search engines such as www.yahoo.com, www.excite.com, www.lycos.com and www.metacrawler.com among others. You can use these search engines directly by typing in their URL or you can click on Search from the Netscape or Internet Explorer menu. There are also a number of websites that provide definitions of networking and computer related terms and acronyms. These can be used to help learn more about networking and to do research on the Internet. Two of these are www.whatis.com and www.webopedia.com. Most websites contain "hyperlinks" which are words that are underlined and highlighted. By clicking on a hyperlink you will "jump" to another page on the current site or to a page another website.

Tools / Preparation:

Before you begin, the teacher or lab assistant will have a typical desktop Pentium-based (or comparable) PC available with the following software installed. The PC should be a classroom computer configured to access the web-based Cisco curriculum and assessment system. You should also review Semester 1 online Chapter 1. The following resources will be required:

- A computer running Windows 95, 98, NT or 2000
- Netscape or Internet Explorer software CD-ROM (if not already installed on the computer)

- Access to the Internet via an Internet Service Provider (ISP) using a LAN or dialup

Worksheet

1. Install Netscape or Internet Explorer on your computer (if it has not already been done).
2. If you are on a LAN (Local Area Network), start the web browser (either Netscape or Internet Explorer). If you are using a modem to make the connection, you must dial your ISP before you can start your web browser.
3. What version of Netscape or Internet Explorer are you using?

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4. After you start your browser, click and highlight the Location field (with Netscape) or Address field (with Internet Explorer) in the toolbar at the top of the page. Press the DELETE key to delete the current address.
5. When your location or address field is empty, type in **www.cisco.com** to get to the Cisco website. This is how you can navigate from one site to another on the World Wide Web (WWW).
6. Load a new page (type in a new location, for example, **www.nba.com**). Notice the status on the bottom bar of your browser. What do you see?

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7. Each of the buttons on top of your browser has a function. Click on the Back button. What did it do?

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8. Click on the Forward button. Does it take you to the NBA website?

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9. Try clicking on the Reload or Refresh button. What do you think they do?

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10. Type in a new website address and click on the Stop button. What happens?

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11. Enter the URL for a search engine such as www.metacrawler.com. Search for the word BROWSER. What was the result?

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12. Enter the URL for www.webopedia.com. Enter the keyword of BROWSER. What was the result?

13. What other hyperlinks were available?

Reflection Questions:

1. Identify a way in which you can navigate from one site to another.

2. If you see the same graphics or text the next time you go to the NBA site, what should you do to ensure that you could look at updated news?

Lab 1.2.3 Basic Troubleshooting

Estimated time: 30 min.

Objectives:

- Learn the proper sequence for troubleshooting computer and network related problems
- Become familiar with some of the more common hardware and software problems
- Given a basic problem situation, be able to troubleshoot and resolve the problem

Background:

The ability to effectively troubleshoot computer related problems is an important skill. The process of identifying the problems and trying to solve it requires a systematic step-by-step approach. This lab will introduce some basic hardware and software related problems to solve and will help you become more familiar with PC components and the software required to use the Cisco curriculum. The process of trying to solve a problem is fairly straightforward. Some of the suggestions here are more than will be required to solve basic hardware and software problems but they will help provide a framework and guidelines when more complex problems arise:

Step 1 - Gather information:

- Observe the symptoms and try to characterize or identify the problem.
- Try to describe what is happening or not happening using proper terminology.
- Ask a coworker if they have encountered a similar problem.
- Get the opinions of others who may have more experience.
- Check websites and troubleshooting knowledge databases.

Step 2 - Isolate the problem:

- Is it hardware (check for lights and noises) or software (errors on screen) related?
- Use substitution to isolate the problem if there is more than one component (if monitor does not work it could be the monitor, video adapter or cables).
- Is it local (this workstation only) or remote (possible network-wide problem)?
- Does it affect this software only or more than one application?
- Is this the first time it has happened or has it happened before?
- Was anything changed recently?

Step 3 - Select one or more possible causes and identify potential solutions:

- Rank them in order of most likely to least likely cause.
- Check the simplest possible causes first (Is the power turned on? Is it plugged in?).
- Check the easiest to check problems first (Try a system reboot).
- Verify hardware first then software (Do any lights come on?).

- Troubleshoot from the bottom up. Start with the physical then move to logical (check the NIC before the IP address).

Step 4 - Test the most likely solution based on your best guess and check the results

Step 5 - When you think you have found the problem and corrected it, double check to make sure everything still works.

Tools / Preparation:

Before you begin, the teacher or lab assistant will have a typical desktop Pentium-based (or comparable) PC available. The PC should be a classroom computer configured to access the web-based Cisco curriculum and assessment system. You should also review Semester 1 online Chapter 1. The following resources will be required:

- A computer running Windows 95, 98, NT or 2000
- Netscape or Internet Explorer software CD-ROM (if not already installed on the computer)
- Access to the Internet via an Internet Service Provider (ISP) using a LAN or dialup

1. Work in teams of two. Team member A (or the instructor) will select two problems from the list of common hardware and software related problems (see answer section) and introduce the problems into the computer. The desired goal will be to view the Semester 1 curriculum and quizzes. Team member A (or the instructor) should create the hardware or software related problems with the computer while the other is out of the room and then turn off the computer and monitor.
2. When team member B identifies the problems and corrects them, switch places and have the other introduce some new problems.
3. Each team member solving the problem should fill in the table based on the symptoms observed, problems identified and solutions to the problem.

Team Member A

	Symptom observed	**Problem identified**	**Solution**
1st problem			
2nd problem			

Team Member B

	Symptom observed	**Problem identified**	**Solution**
1st problem			
2nd problem			

Lab 1.3.6 Binary Numbering

Estimated time: 30 min.

Objectives:

This lab will focus on your ability to accomplish the following tasks:

- Identify the positions in a binary number and know the value of each
- Identify the positions in a decimal number and know the value of each
- Work with Base 10 exponents (powers of 10) and understand how position defines value
- Work with Base 2 exponents (powers of 2) and understand how position defines value
- Manually convert simple binary numbers and decimal numbers
- Manually convert 32-bit binary IP addresses and dotted decimal IP addresses
- Use the Windows Scientific Calculator to check your answers (go to the View Menu in the calculator window and select the Scientific option)
- Describe the differences between binary and decimal numbering systems

Background:

This lab will help you learn to work with the binary numbering system. You will convert binary numbers (Base 2) to decimal numbers (Base 10) and decimal to binary. Computers and networking equipment such as routers work with binary numbers, a series of BITS (short for Binary Digits), which are either ON (a binary 1) or OFF (a binary 0). They are encoded internally in the PC and on networking media (cables) as either electrical voltages on copper cable such as Unshielded Twisted Pair (UTP) or as light pulses on fiber cable. The current version of the Internet Protocol (IPv4) uses a 32-bit address (usually divided into four "octets" or 8-bit bytes) to identify a particular network and a host on that network. Humans are more comfortable working with decimal numbers, so IP addresses are usually written as four decimal numbers separated by periods (dots), each representing an octet, to make them easier to read. This is referred to as "dotted decimal notation". Understanding binary numbers and how they relate to decimal numbers is critical to understanding IP addresses, subnets and network routing.

Tools / Preparation:

This is primarily a written lab exercise but you will use the Windows Scientific Calculator so you will need access to a PC. You may want to refer back to Lab 1.2.1.1 -- TCP/IP Network Settings for some real IP addresses to convert. The following resources will be required:

- PC workstation with Windows operating system (Win 95, 98, NT, or 2000) installed on PC and access to the Windows Calculator.

Notes:

Step 1 - Decimal Numbers.

Explanation: We are most familiar with "decimal" numbers (Base 10). The decimal numbering system is based on the powers of 10. This exercise will help develop an understanding of the exponentiation or "powers" of numbers using the Base 10 number system. The Base 10 system is what our arithmetic and money system is based on. With Base 10, the right-most position has a value of 1 (same as Base 2). Each position moving to the left is worth 10 times more. 10 to the zero power (10^0) is one, 10 to the first power (10^1 or 10 x 1) is 10, 10 to the second power (10^2 or 10 x 10) is 100 and 10 to the third power (10^3 or 10 x 10 x 10) is 1,000 and so on. Just multiply the number in each position times the value of each position (for example, 400 = 4 x 10^2 or 4 x 100). Remember any number to the zero power is 1.

Decimal Number Conversion Example.

The following chart shows how the decimal number system represents the number 352,481. This will help in understanding the binary numbering system.

Exponent	10^6	10^5	10^4	10^3	10^2	10^1	10^0
Position	7	6	5	4	3	2	1
Value	1000000	100000	10000	1000	100	10	1
Number	0	3	5	2	4	8	1
	0 x 1,000,000	**3 x 100,000**	**5 x 10,000**	**2 x 1,000**	**4 x 100**	**8 x 10**	**1 x 1**

The number 352,481 if read from right to left would be (1 x 1) + (8 x 10) + (4 x 100) + (2 x 1,000) + (5 x 10,000) + (3 x 100,000) for a total of 352,481 (a six-digit number).

Here is another way to look at it that makes it easier to add up the decimal number values:

Position of digit (from right)	**Value of bit position (10^X or ten to the power of)**	**Number value from 0 to 9**	**Calculation**	**Decimal Value**
1st Decimal Digit	10^ 0 or 1	1	1 x 1	1
2nd Decimal Digit	10^ 1 or 10	8	8 x 10	80
3rd Decimal Digit	10^ 2 or 100	4	4 x 100	400
4th Decimal Digit	10^ 3 or 1000	2	2 x 1,000	2,000

5th Decimal Digit	10^ 4 or 10000	5	5 x 10,000	52,000
6th Decimal Digit	10^ 5 or 100000	3	3 x 100,000	300,000
Decimal Value (Total of 6 digits)				**352,481**

Step 2 - Binary Numbers

Explanation: Binary means "two" and each digit in a binary number can only have two values, 0 (zero) or 1. It is also called a Base 2 numbering system. Binary numbers are the key to understanding how routers work and how packets get from one workstation (host) to another server (host) on a TCP/IP network. Internet addresses are made up of 32 bits or four groups of eight bits known as "OCTETS". Each bit of each octet has a value based on its position. Of the eight bits in an octet, the left-most bit is worth 128 (2^7) and the right most bit is worth 1 (2^0). The value of each bit is based on the powers of 2.

The binary numbering system is based on the powers of 2. This exercise will help develop an understanding of exponentiation or "powers" of numbers using the Base 2 number system, which is what all computers and data communications use. With Base 2, the right-most position has a value of 1 as with Base 10. Each position moving to the left is worth 2 times more. 2 to the zero power (2^0) is one, 2 to the first power (2^1 or 2 x 1) is 2. 2 to the second power (2^2 or 2 x 2) is 4 and 2 to the third power (2^3 or 2 x 2 x 2) is 8, and so on. Just multiply the number in each position (either a 0 [zero] or a 1) times the value of each position (for example, 8 = 1 x 2^3 or 1 x 8) and add up the total. Remember any number to the zero power is 1. Convert the following binary numbers to decimal numbers. In the first exercise you will convert a binary number to a decimal number. Starting from the right, the first binary digit is a zero which is calculated as zero times 2^0 (2 to the zero power or 0 x 1). Anything to the zero power is 1. The second position from the left is also a zero so this is zero times 2^1 (or 0 x 2). The third binary number from the right is a 1. This is 1 times 2^2 (2 to the 2nd power, or 4).

Binary Number Conversion Example.

The following table shows the detail calculations (starting from the right side) to convert the binary number 10011100 into a decimal number.

Position of digit (from right)	Value of bit position (two to the power of)	Is bit a One (on) or a Zero (Off)	Calculation	Decimal Value
1st Binary Digit	2^ 0 or 1	0	0 x 1	0
2nd Binary Digit	2^ 1 or 2	0	0 x 2	0
3rd Binary Digit	2^ 2 or 4	1	1 x 4	4
4th Binarv	2^ 3 or 8	1	1 x 8	8

Digit				
5th Binary Digit	2^ 4 or 16	1	1 x 16	16
6th Binary Digit	2^ 5 or 32	0	0 x 32	0
7th Binary Digit	2^ 6 or 64	0	0 x 64	0
8th Binary Digit	2^ 7 or 128	1	1 x 128	128
Decimal Value (Total of 8 digits)				156

Step 3 - Binary to Decimal Practice Exercises.

Task: Practice converting the four binary octets of an IP address to the dotted decimal equivalent.
Explanation: Look at the Binary Number Bit Status row in the chart below. If there is a 1 in a position add the value shown. If there is a 0 (zero) in a position then do not add it. Note that eight bits cannot represent a decimal number greater than 255 (If all eight positions are 1s then 128 + 64 + 32 + 16 + 8 + 4 + 2 + 1 = 255).

1. Solve for the 1st , 2nd , 3rd and 4th octet decimal value

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary Number Bit Status	1	0	0	1	1	1	0	0

1st Octet Decimal Value:_____________________

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary Number Bit Status	1	1	1	0	0	0	1	1

2nd Octet Decimal Value:_____________________

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary	0	1	1	1	0	0	0	0

Number Bit Status								

3rd Octet Decimal Value:____________________

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary Number Bit Status	1	1	0	1	1	0	1	0

4th Octet Decimal Value:____________________

1. Enter the Dotted Decimal octet values for all four octets for the above IP address:

10011100 . 11100011 . 01110000 . 11011010

Step 4 - Decimal to Binary Practice Exercises.

Task: Practice converting the following decimal values of the IP address 209.114.58.165 to the binary octet equivalent.
Explanation: Look at the decimal value and then subtract binary values starting from 128 (the highest value binary bit). If the number is larger than 128, then put a 1 in the first position binary number bit status. Subtract 128 from the number and then see if there is a 64 left. If there is, put a 1 there, otherwise put a 0 (zero) and see if there is a 32. Continue until all eight bits are defined as either a 0 (zero) or a 1.

1. Solve the 1st , 2nd , 3rd and 4th octet decimal value to binary bit number

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary Number Bit Status								

1st Octet Binary Value:____________________

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary Number Bit Status								

2nd Octet Binary Value:____________________

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary Number Bit Status								

3rd Octet Binary Value:____________________

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary Number Bit Status								

4th Octet Binary Value:____________________

2. Enter the eight Binary bits (0s [zeros] and 1s) octet values for all four octets for the IP address:

209 . 114 . 58 . 165

________ ________ ________ ________

Lab 2.3.4 OSI Model and TCP/IP - Overview

Estimated time: 20 min.

Objectives:

This Lab will focus on your ability to accomplish the following tasks:

- Describe the four layers of the TCP/IP model
- Relate the seven layers of the OSI model to the four layers of the TCP/IP model
- Name the primary TCP/IP protocols and utilities that operate at each layer

Background:

This lab will help you develop a better understanding of the seven layers of the OSI model as they relate to the most popular functioning networking model in existence, the TCP/IP model. The Internet is based on TCP/IP, which has become the standard language of networking. Although the TCP/IP model is the most widely used, the seven layers of the OSI model are the ones most commonly used to describe and compare networking software and hardware from various vendors. It is very important to know both the OSI and TCP/IP models and be able to relate (or map) the layers of one to the other. An understanding of the TCP/IP model and the protocols and utilities that operate at each layer is essential when troubleshooting.

Tools / Preparation:

You may work individually or in teams. The following resources will be required:

- PC workstation with Monitor, keyboard, mouse, and power cords
- Windows operating system (Win 95, 98, NT, or 2000) installed on PC
- NIC installed and Cat 5 patch cable with connection to the Internet
- Browser software installed (Netscape Navigator 4.6.1 or higher or Internet Explorer 5.1 or higher
- Java, JavaScript, and Style Sheets (must be enabled in your browser's preference settings)
- Flash plug-in
- Sample Ethernet and Token Ring NICs with different connectors (Coax, AUI, RJ-45)
- Sample Hubs, Switches and Routers

Notes:

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Step 1 - The OSI model and associated TCP/IP protocol stack layer.

Task: Fill out the following charts based on your knowledge of the OSI model and TCP/IP models.
Explanation: Your understanding of the OSI model as it relates to the TCP/IP model will greatly increase your ability to absorb and categorize networking information as you learn it.

1. List the seven layers of the OSI model from the top to the bottom with the proper name for each layer. List the TCP/IP layer number and its correct name in the next columns. Also list the term used for the encapsulation units, the related TCP/IP protocols / utilities and the devices that operate at each layer.

NOTE:

More than one OSI layer will be related to certain TCP/IP layers.

OSI comparison with TCP/IP Protocol Stack

OSI #	OSI Layer Name	TCP/IP #	TCP/IP Layer name	Encapsul. Units	TCP/IP Protocols At each TCP/IP layer
7					
6					
5					
4					
3					
2					
1					

Lab 2.3.5 OSI Model - Overview

Estimated time: 20 min.

Objectives:

This Lab will focus on your ability to accomplish the following tasks:

- Name the seven layers of the OSI model in order using a mnemonic (memory jogger)
- Describe the characteristic, functions and keywords relating to each layer
- Describe the packaging units used to encapsulate each layer
- Name several protocols and standards that operate at each layer

Background:

This lab will help you develop a better understanding of the seven layers of the OSI model. You will identify the characteristics of each layer as well as the terminology at each layer. The OSI model was developed by the ISO to help provide a common framework for the development of both Local Area Networks (LANs) and Wide Area Networks (WANs). Most network architectures and companies do not adhere exactly to the OSI model but use it to describe their products and compare them to others. The OSI model helps us troubleshoot networking problems by breaking down the networking process (communication from hosts to servers) into distinct layers where functions must occur and identifying tools which can help to isolate the problem. An understanding of the OSI model is essential to success in the world of networking. This lab focuses on the Ethernet network architecture and the Internet Protocol suite (TCP/IP).

Tools / Preparation:

You may work individually or in teams. The following resources will be required:

- PC workstation with monitor, keyboard, mouse, and power cords
- Windows operating system (Win 95, 98, NT, or 2000) installed on PC
- NIC installed and Cat 5 patch cable with connection to the Internet
- Browser software installed (Netscape Navigator 4.6.1 or higher or Internet Explorer 5.1 or higher
- Java, JavaScript, and Style Sheets (must be enabled in your browser's preference settings)
- Flash plug-in

Notes:

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Step 1 - The OSI model and associated TCP/IP protocol stack layer.

Task: Fill out the following charts based on your knowledge of the OSI model.
Explanation: Your understanding of the OSI model will greatly increase your ability to absorb and categorize networking information as you learn it.

1. List the seven layers of the OSI model from the top to the bottom. Give a mnemonic word for each layer that can help you remember it and then list the keywords and phrases that describe the characteristics and function of each.

Layer #	Name	Mnemonic	Key Words and Description of Function
7			
6			
5			
4			
3			
2			
1			

2. List the seven layers of the OSI model and the encapsulation unit used to describe the data grouping at each layer.

Layer #	Name	Encapsulation Unit or Logical Grouping
7		
6		
5		
4		
3		
2		
1		

Lab 3.4.2 Basic LAN Setup

Estimated time: 60 min.

Objectives:

- Create a simple LAN with two PCs using a single crossover cable to connect the workstations
- Create a simple LAN with two PCs using an Ethernet hub and two straight-through cables to connect the workstations
- Connect the hub-based mini-LAN to the Internet if a connection is available
- Use the Control Panel / Network utility to verify and configure the network settings
- Use the ICMP Ping command to verify the TCP/IP connection between the two workstations
- Use the WINIPCFG.EXE (Windows 95 or 98) or IPCONFIG.EXE (Windows NT or 2000) utility to verify all IP configuration settings

Background:

In this lab you learn how to connect two PCs to create a simple Peer-to-Peer LAN or workgroup. The instructions for this lab focus on the Windows 95, 98, NT or 2000 operating system. You will share a folder on one workstation and connect to that folder from the other workstation. This lab is divided into three exercises as follows:

Exercise A -- The two PCs (or workstations) will be connected directly to each other from one Network Interface card (NIC) to the other NIC using a crossover cable. This can be useful to allow you to create a minilab for testing purposes without the need for a hub. Since the NICs on the workstations are directly connected you will not be able to connect any additional workstations.

Exercise B -- The two PCs will be connected with a hub between them. Using a hub allows for more than just two workstations to be connected depending on the number of ports on the hub. Hubs can have anywhere from four to twenty four ports.

NOTE: For both exercises A and B, you will verify that the workstations are functioning and that network hardware is installed properly. You will also need to verify and configure all TCP/IP protocol network settings for the two workstations to communicate such as IP address and subnet mask.

Exercise C (optional) -- The two PCs attached to the hub will be connected to the Internet with another straight-through cable connected to a live hub or switch. You will use your browser to access a website.

Tools / Preparation:

It is best to start with a fresh install of the Windows operating system. The workstations should have Network Interface Cards (NIC) installed with the proper drivers (floppy disk or CD) available. The following resources will be required:

- Two Pentium-based workstations with a NIC in each (NIC drivers should be available)
- Exercise A - One CAT 5 Crossover cable to connect the workstations without a hub
- Exercise B - An Ethernet hub (four or eight port) and two CAT 5 straight-through cables
- Exercise C - A connection to the Internet if available with a third straight-through cable on the hub
- Windows operating system CD-ROM to do fresh install or to use when network setting changes are made

In this lab you will set up a small peer-to-peer Ethernet LAN workgroup using two workstations. Answer the following questions with each step as you check and/or configure the necessary components.

NOTE:

Steps 1 and 2 (physical LAN connections) will be different between exercises A and B. The steps from 3 on should be the same since they relate only to the workstations and should be performed on both workstations.

Step 1 - Check Local Area Network (LAN) Connections

Task: Verify the cables
Explanation: You should check the cables to verify that you have good Layer 1 physical connections

Exercise A - A single CAT 5 crossover cable is used to connect the workstations together. Verify that the pins are wired as a crossover by holding both RJ-45 connectors side by side with the clip down and inspect them. Pairs 2 and 3 should be reversed. Refer to Lab 5.3.4 for correct wire color and pin locations.

Exercise B - Check each of the two CAT 5 cables from each workstation to the hub. Verify that the pins are wired straight-through by holding the two RJ-45 connectors for each cable side by side with the clip down and inspect them. All pins should have the same color wire on the same pin at both ends of the cable (pin 1 should match pin 1 and pin 8 should match pin 8, and so on). Refer to Lab 5.3.2 for correct pin locations.

1. Are the cable(s) wired correctly?

____

Step 2 - Plug in and connect the equipment

Task: Check the workstations (and hub for exercise B)
Explanation:

Exercises A and B - Check to make sure that the NICs are installed correctly in each workstation. Plug in the workstations and turn them on.

Exercise B - Plug the hub or its AC adapter into a power outlet. Plug the straight through cable from workstation 1 into port 1 of the hub and the cable from workstation 2 into port 2 of the hub. After the workstations have booted, check the green link light on the back of each NIC and the green lights on ports 1 and 2 of the hub to verify that the are communicating. This also verifies a good physical connection between the Hub and the NICs in the workstations (OSI Layers 1 and 2). If the link light is not on it usually indicates a bad cable connection, an incorrectly wired cable or the NIC or hub may not be functioning correctly.

1. Are the NIC and hub link lights on?

____

Step 3 - Network Adapters and Protocols.

Task: Check the Network Adapter (NIC): Use the Control Panel, System, Device Manager utility to verify that the Network Adapter (NIC) is functioning properly for both workstations. Double click on Network Adapters and then right click the NIC adapter in use. Click Properties to see if the device is working properly.
Explanation: If there is a problem with the NIC or driver, the icon will show a yellow circle with an exclamation mark in it with (possible resource conflict) or a red X indicating a serious problem (device could cause Windows to lock up).

1. What does the NIC properties window say about the Network Adapter?

____

Step 4 - Check the TCP/IP Protocol Settings:

Task: Use the Control Panel, Network utility and select the TCP/IP protocol from the Configuration Tab and click on properties. Check the IP Address and Subnet mask for both workstations on the IP Address Tab.
Explanation: The IP addresses can be set to anything as long as they are compatible and on the same network. Record the existing settings before making any changes in case they need to be set back (for instance, they may be DHCP clients now). For this lab, use the Class C network address of 200.150.100.0 and set workstation 1 to a static IP address 200.150.100.1 and set workstation 2 to 200.150.100.2. Set the default subnet mask on each workstation to 255.255.255.0.

1. Have the IP addresses and Subnet mask been set?

____

Step 5 - Check the TCP/IP Settings with the WINIPCFG Utility

Task: Use the WINIPCFG.EXE (Windows 95 or 98) or IPCONFIG.EXE (Windows NT or 2000) command to see your TCP/IP settings on one screen. Click on Start, Programs and then select the MS-DOS Prompt.
Explanation: Enter the winipcfg /all or ipconfig /all command (you do not need

the .exe since this is an executable command) to see all TCP/IP related settings for your workstation.

1. Fill in the blanks below using the results of the WINIPCFG or IPCONFIG command from each workstation:

Workstation 1 Name:	**Workstation 2 Name:**
IP Address:	**IP Address:**
Subnet Mask:	**Subnet Mask:**
MAC (Hardware) Address:	**MAC (Hardware) Address:**

Step 6 - Check the network connection with the Ping Utility

Task: Use the Ping Command to check for basic TCP/IP connectivity. Click on Start, Programs and then the MS-DOS Prompt. Enter the Ping command followed by the IP address of the other workstation (Example - **ping 200.150.100.1**).

Explanation: This will verify that you have a good OSI Layers 1 thru 3 connection.

1. What was the result of the Ping command?

____

Step 7 - Windows Networking Options

Task: Check Network Configuration: Use the Control Panel, Network utility, Configuration Tab and check to be sure that you have the following networking components installed:

1. Microsoft Family or Microsoft Windows Logon Client (small computer icon).
2. The NIC adapter (small NIC icon).
3. The TCP/IP Protocol (small network cable connection icon).

There may be other adapters and protocols listed but these are the ones required for this lab. Click on the Access Control Tab and verify that the "Share Level Access Control" button is selected. Select the Microsoft Family or Windows client and click properties. Click on the Identification Tab and enter a name for the first computer of PC1. Name the other computer PC2. The Workgroup should be WORKGROUP and the Computer Description is optional.

Explanation: You may need to reboot the computer and if prompted insert the Windows CD.

1. List the Networking components installed:

Client (computer icon)	
Adapter (NIC icon)	

Protocol (net connection icon)	
Other Client / Adapter / Protocol	

Step 8 - Check File and Print Sharing:

Task: Use the Control Panel, Network utility, Configuration Tab and click the File and Print Sharing button. On the workstation that will have the folder to be shared, check the box that says "I want to be able to give others access to my files" to allow each workstation to share its Folders. You can also check the box that says "I want to be able to allow others to print to my printers" to allow the other workstation to print if you have a shared printer attached to one of the workstations.

Step 9 - File Folders and Sharing Options

Task: Set up a File folder to share: On workstation one, use Windows Explorer to create a folder to be shared called "Test folder". Using Windows Explorer, My Computer or Network Neighborhood, select the folder and right click to share it. Enter the name of the share and click OK. From the other workstation, click on Network Neighborhood and select the first workstation and the shared folder. **Explanation:** You can map a drive to the shared folder if you wish. While working in the shared folder on the other workstation, create a new document and save it. If you have a printer shared you may want to print the document.

1. Document the results of the folder sharing and file creating process:

____

____

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Lab 4.2.1 Safe Handling and Use of a Multimeter

Estimated time: 15 min.

Objectives:

- Learn how to use or handle a multimeter correctly.

Background:

A multimeter is a powerful electrical testing tool that can detect voltage levels, resistance levels and open/closed circuits. It can check both alternating current (AC) and direct current (DC) voltage. Open and closed circuits are indicated by resistance measurements in Ohms. Each computer and networking device consists of millions of circuits and small electrical components. A multimeter can be used to debug electrical problems within a computer/networking device or between networking devices.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have several multimeters available (one for each team of two students) and various batteries for testing. Work in teams of two. You should review Semester 1 online Chapter 4. The following resources will be required:

- A digital multimeter (Fluke 12B or similar) for each team
- A manual for the multimeter
- A battery (for example, a 9v, 1.5V, or lantern, it does not matter) for each team to test.

Notes:The multimeter is a sensitive piece of electronic test equipment. Be sure that you do not drop it or throw it around. Be careful not to accidentally nick or cut the red or black wire leads (probes). Since it is possible to check high voltages, extra care should be taken when doing so to avoid electrical shock.
Worksheet

Perform the following steps to become familiar with the handling of the multimeter.

Step 1 - Insert the red and black leads (probes) into the proper jacks on the meter. The black probe should go in the COM jack and the red probe should go in the + (plus or positive) jack.

Step 2 - Turn on the multimeter (click/turn to the on button). What model of multimeter are you working with? ____________________________ What action must you take to turn the meter on? ___________

____

Step 3 - Switch or turn to different measurements (for example, voltage, ohms, and so on). How many different switch positions does the multimeter have? ________ What are they? ________________

Step 4 - Switch or turn the multimeter to the voltage measurement. What is the symbol for this? ____________

Step 5 - Put the tip of the red (positive) lead on one end of a battery (+ side), battery and put the tip of the black (negative) lead on the other end of a battery. Is any number showing up on the multimeter? ____________ If not, make sure you switch to the correct type of measurement (Vol, voltage, or V). If the voltage is negative, reverse your leads.

Reflection Questions:

1. Name one thing that you should not do to a multimeter.
2. Name one important function of a multimeter.
3. If you get a negative voltage when measuring a battery, why is that?

Lab 4.2.2 Resistance Measurements

Estimated time: 30 min.

Objectives:

- Demonstrate your ability to measure resistance and continuity with the multimeter.

Background:

The digital multimeter is a versatile testing and troubleshooting device. In this lab you will learn how to perform resistance measurements, and related measurements called continuity. Resistance is measured in Ohms (indicated by the Greek letter Omega or Ω. Copper wires (conductors) such as those commonly used in network cabling (UTP and coax) normally have very low resistance or "good" continuity (the wire is continuous) if you check them from end to end. If there is a break in the wire it is called an "open" which creates very high resistance (air has nearly infinite resistance indicated by the infinity symbol or ∞, a sideways eight). The multimeter has a battery in it that it uses to test the resistance of a conductor (wire) or insulator (wire sheathing). When the probes are applied to the ends of a conductor, the battery current flows and the meter measures the resistance it encounters. If the battery in the multimeter is low or dead you must replace it or you will not be able to take resistance measurements.

With this lab you will test common networking materials so that you can become familiar with them and their resistance characteristics. You will first learn to use the resistance setting on the multimeter. As you measure small resistances, you should also note the continuity feature. The instructions provided are for the Fluke 12B. Other meters will function in a similar way.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have several multimeters available (one for each team of two students) and various networking related items for testing resistance. Work in teams of two. You should review Semester 1 online Chapter 4. The following resources will be required:

- Fluke 12B multimeter or equivalent
- 1000 Ohm resistor
- 10,000 Ohm resistor
- Pencil for creating graphite paths on paper
- Cat 5 jack
- Small (0.2m or appx 6 to 8 inches) section of Cat 5 UTP solid cable
- BNC terminated coaxial cable
- Unconnected DB9 to RJ-45 adapter
- Terminated Cat 5 UTP patch cable

Step 1 - Move the rotary selector to the Omega symbol for Ohms (red Ω) in order to measure resistance.

Press the button that has the Ohms symbol (red Ω) on it to select between resistance measurements and continuity.

Resistance Measurements: The screen will show Ω (ohms), KΩ (kilohms = thousands of Ohms) or MΩ (megohms = Millions of Ohms). Use the Range button to change the range of resistance to be measured based on what resistance you expect to get. If you expect low resistance (less than 10 ohms), select a low scale (like Ω). If you expect a high reading (over 10,000 ohms), select a high scale (like KΩ). If the resistance reading is over the range selected, the OL or Over Limit indicator will be displayed on the screen. The resistance setting is for measuring exact amounts of resistance.

Continuity Measurements: The screen will show a diode symbol which is a small black triangle pointing to a vertical bar. A diode is an electronic device that either passes or blocks electrical current. You may see a small sound symbol next to it, which means that when there is good continuity (no resistance) the beep will sound. The continuity setting is used when you just want to know if there is a good path for electricity or not and do not care about the exact amount of resistance.

Step 2 - Check the following resistances. Turn the meter off when finished or battery will drain.

Item to Measure the resistance of:	**Set Selector and range scale to:**	**Resistance reading:**
1000 Ω Resistor		
10 kΩ Resistor		
Graphite marking from a pencil on a piece of paper		
Cat 5 jack		
0.2 m section of Cat 5 UTP solid cable		
Touch red and black probe contacts together		
Your own body (touch the tips of the probes with your fingers)		
BNC terminated coaxial cable		
Unconnected DB9 to RJ-45 adapter		
terminated Cat 5 UTP patch cable		

Reflection Question:

What purpose might the multimeter serve in maintaining and troubleshooting a computer network?

___

Lab 4.2.3 Voltage Measurement

Estimated time: 30 min.

Objectives:

- Demonstrate your ability to measure voltage SAFELY with the multimeter

Background:

The digital multimeter is a versatile testing and troubleshooting device. In this lab, you will learn how to perform both direct current (DC) and alternating current (AC) voltage measurements. Voltage is measured in either AC or DC volts (indicated by a V). Voltage is the pressure that moves electrons through a circuit from one place to another. Voltage differential is essential to the flow of electricity. The voltage differential between a cloud in the sky and the earth is what causes lightning to strike.

NOTE: It is very important to be careful when taking voltage measurements since it is possible to receive an electrical shock.

Direct Current (DC): DC voltage rises to a set level and then stays at that level and flows in one direction (positive or negative). Batteries produce DC voltage and are commonly rated at 1.5v or 9v (flashlight batteries) and 6v (lantern and vehicle batteries). Typically the battery in your car or truck is a 12v battery. When an electrical "load" such as a light bulb or motor, is placed between the positive (+) and negative (-) terminals of a battery, electricity flows.

Alternating Current (AC): AC voltage rises above zero (positive) and then falls below zero (negative) and actually changes direction very rapidly. The most common example of AC voltage is the wall outlet in you house or business. These outlets provide approximately 120 volts AC directly to any electrical appliance that is plugged in such as a computer, toaster or television. Some devices such as small printers and laptop computers have a transformer (small black box) that plugs into a 120V AC wall outlet and then converts the AC voltage to DC voltage for use by the device. Some AC outlets can provide a higher voltage of 220V for use by devices and equipment with heavier requirements such as clothes dryers and arc welders.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have several multimeters available (one for each team of students) and various items for testing voltage. Work in teams of two. You should review Semester 1 online Chapter 4. The following resources will be required:

Required voltage measurement items:

- Fluke 12B multimeter (or equivalent)
- An assortment of batteries: A cell, C cell, D cell, 9 Volts, 6 V lantern
- Duplex wall outlet (typical 120v)
- Power supply (for laptop, or other networking electrical device)

Optional voltage measurement items:

- A lemon, with a galvanized nail stuck in one side, and a piece of uninsulated copper wire stuck in the opposite side.
- Solar cell with leads attached.
- Homemade generator (wire wound around a pencil 50 times and a magnet).

Step 1 - Move the rotary selector to the V symbol for voltage (black V) in order to be able to measure.

Press the button that has the VDC and VAC symbol to select between direct current (DC) or alternating current (AC) measurements.

Direct Current Measurements: The screen will show a V (voltage) with a series of dots and a line over the top. There are several scales available depending on the voltage to be measured. They start from millivolts (abbreviated mV = 1,000/th of a volt) to voltages up to hundreds of volts. Use the Range button to change the range of DC voltage to be measured based on what voltage you expect to measure. Batteries (less than 15 volts) can typically be measured accurately with the VDC scale and 0.0 range. DC voltage measurements can be used to determine if batteries are good or if there is voltage coming out of an AC adapter (transformer or converter) which are very common and used with hubs, modems, laptops, printers and other peripherals. These adapters can take wall outlet AC voltage and step it down to lower AC voltages for the device attached or can convert the AC voltage to DC and step it down. Check the back of the adapter to see what the input (AC) and output voltages (AC or DC) should be.

Alternating Current Measurements: The screen will show a V (voltage) with a tilde or (~) after it. This represents alternating current. There are several scales available depending on the voltage to be measured. They start from millivolts (abbreviated mV = 1,000/th of a volt) to voltage up to hundreds of volts. Use the Range button to change the range of AC voltage to be measured based on what voltage you expect to measure. Voltage from power outlets (120v or greater) can typically be measured accurately with the VAC scale and 0.0 range. AC voltage measurement is useful in determining if there is adequate voltage coming from an AC outlet to power the equipment plugged in.

Use a Fluke 12B multimeter (or equivalent) to measure the voltage of each of the following:

Step 2 - Check the following voltages. Be sure to turn the meter off when finished.

Item to Measure the Voltage of:	**Set Selector and range scale to:**	**Voltage reading:**
Batteries: A cell (AA, AAA) , C cell, D cell, 9 Volts, 6 V lantern		

Duplex wall outlet (typical 120v)		
Power supply (converts AC to lower AC or DC) for laptop, mobile phone or other networking electrical device		
(Optional) A lemon, with a galvanized nail stuck in one side, and a piece of uninsulated copper wire stuck in the opposite side		

Reflection Question:

Why might you want to measure voltage when troubleshooting a network?

Lab 4.2.4 Series Circuits

Estimated time: 30 min.

Objectives:

- Build series circuits and explore their basic properties.

Background:

One of the most basic concepts in electronics is that of a continuous loop through which electrons flow, and which is called a circuit. Throughout networking there are references to ground loop circuit, circuit versus packet switching, virtual circuits, in addition to all of the real circuits formed by networking media and networking devices. One of the fundamental electrical circuits is the SERIES circuit. While most networking devices and networks are built from very complex circuits that are beyond the scope of the lessons included in this course, the process of building some series circuits will help you with some of the terminology and concepts of networking. This lab will also help increase your overall understanding of some of the most basic electrical circuit building blocks.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have several multimeters available (one for each team of students) and various items for testing voltage. Work in teams of two. The following resources will be required:

- Fluke 12B multimeter (or equivalent)
- Light switch
- Wire cutters/stripper
- Copper Wire
- 2 light bulbs (6v) with bulb bases
- 6-Volt lantern battery

Notes:

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Step 1 - Measure the resistances of all devices and components except the battery.

Measure the voltage of the battery. All resistances should be less than 1 Ω (Ohm), except the light bulbs. All the devices except the battery should register continuity (with the tone) indicating a short circuit, or a conducting path.

Check the following resistance. Turn the meter off when finished or it will drain the battery.

Item to Measure the resistance of:	Set Selector and range scale to:	Resistance reading:
Pieces of wire to connect components		
Light switch		
Light bulbs		

Step 2 - Measure the voltage of the battery, unloaded (with nothing attached to it).

Item to Measure the Voltage of:	Set Selector and range scale to:	Voltage reading:
Lantern Battery: (6 V) with no load		

Step 3 - Build a series circuit, one device at a time (use 1 battery, 1 switch, 1 bulb and connecting wires).

Connect the battery positive lead to one end of wire and connect the negative lead to the other wire. If the switch is turned on, the bulb should light. Disconnect one thing and see that the circuit is broken. Did the bulb go out?

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Step 4 - Measure the battery voltage while the circuit is running.

The switch should be turned on and the light bulb should be lit. What was the voltage of the battery with the light bulb on?

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Step 5 - Add the second bulb in series and measure the battery voltage again.

What was the voltage of the battery with the light bulb on?

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Reflection Question:

How do series circuits apply to networking?

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Lab 4.2.5 Communications Circuit

Estimated time: 50 min.

Objectives:

- Design, build, and test a simple, complete, fast, and reliable communication system, using common materials.

Background:

For reliable communications to take place on a network many things must be defined ahead of time. This includes the physical method of signaling and the meaning of each signal or series of signals. With this lab, you will create a very simple physical network and agree on some basic rules for communication in order to send and receive data. This will be a digital network based on the American Standard Code for Information Interchange (ASCII). It will be somewhat similar to the old telegraph Morse code based systems where the only means of communicating over long distance was by sending a series of dots and dashes as electrical signals over wires between locations. While the technology used will be much simpler than real systems, many of the key concepts of data communications between computers will arise. This lab will also help to clarify the functions of the layers of the OSI model.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have several multimeters available (one for each team of students) and various items for construction of a simple communication network. Work in teams of two to four. The following resources will be required. Be sure to review the purpose of each of the required items listed below since it will help in designing your network.

Network construction item Required	**Purpose**
Fluke 12B multimeter (or equivalent)	For testing communication connections
20' - Cat 5 UTP cable	For the physical communications lines (the cabling medium)
ASCII chart	To help with coding and interpretation of signals (If you do not have a hardcopy of the 7-bit ASCII code chart, search for the Internet for the words "ACSII chart" and you will find several listed)
Light switch	To activate the signaling device in order to create the digital on/off (binary) signals
Light bulbs (6v) with bulb bases (as an alternative use LEDs with current-limiting resistors)	To act as the signaling device
6-Volt lantern battery	To power the signaling device
Wire cutters/stripper	To adjust the length and prepare the ends of the communication lines

Lab Goals:

Your group must design, build, and test a communications circuit with another team. You must communicate as much data as possible, quickly and with as few errors as possible. Spoken, written, or miscellaneous nonverbal communication of any kind is not allowed. Only communication over the wire is allowed. You will agree as a team on the physical connections and on the coding you will use. One of the main goals is to send a message to the other team and have them interpret what you intended without them knowing ahead of time what your message was. Keep the OSI model in mind as you design your system.

1. Layer 1 issues - You must connect two pairs of wire in order to have communication in both directions (half or full duplex.)
2. Layer 2 issues - You must communicate some sort of frame start and stop sequence. This is a sequence of bits that is different than the character and number bits you will be transmitting.
3. Layer 3 issues - You must invent an addressing scheme (for hosts and networks) if it is more than point-to-point communication.
4. Layer 4 issues - You must include some form of control to regulate quality of service (for example, error correction, acknowledgment, windowing, flow controls, and so on).
5. Layer 5 issues - You must implement some way of synchronizing or pausing long conversations.
6. Layer 6 issues - You must use some means of data representation (for example, ASCII encoded as optical bits).
7. Layer 7 issues - You must be able to communicate an idea supplied by your instructor or come up with a message on your own.

Reflection Questions:

1. What issues arose, as you tried to build your communications system, that you think apply to data communications between computers?

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2. Analyze your communications system in terms of the OSI layers.

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Lab 5.3.1 Basic Cable Tester

Estimated time: 30 min.

Objectives:

- Use a cable tester to verify that a straight-through or crossover cable is good or bad

Background:

UTP Ethernet Cabling: Cabling is one of the most critical areas of network design and implementation. The cabling is expected to last from 10 to 15 years. The quality of cable and connections is a major factor in reducing network problems and time spent troubleshooting. Unshielded Twisted Pair (UTP) copper cable is the most common cable used in Ethernet networks. There are various Categories (CAT 3, CAT 5, CAT 5e, and so on) but all of them contain eight wires or conductors and use RJ-45 connectors. A UTP patch cable in a network is usually wired as a straight-through or crossover. In order to follow proper specifications, all eight conductors must be used even though with most earlier versions of Ethernet, not all eight conductors were used. You will create these cables in the future labs. In this lab you will work with several cables that have already been made and will test them for basic continuity (breaks in wires) and shorts (two or more wires touching) using a basic cable tester (refer to the lab on resistance measurements).

Basic Cable Testers: There are a number of very simple and inexpensive basic cable testers available (less than $100). They usually consist of one or two small boxes with RJ-45 jacks to plug the cables to be tested into. Many of these are designed specifically to test only Ethernet UTP type of cable. The testers will have more than one jack to allow for testing of straight-through or crossover cable. Both ends of the cable are plugged in to the proper jacks and the tester will test all eight wires and indicate whether the cable is good or bad. If any of the eight wires has a break or is shorted to any of the other wires, the cable is bad. The simple testers may just have a single light to indicate this. Others may have eight lights to tell you which wire is bad. These testers have internal batteries and are doing continuity checks on the wires.

Advanced Cable Testers: Advanced cable testers, such as the Fluke 620 LAN CableMeter, are sophisticated cable testers that have basic cable testing functions and much more. You will use an advanced cable tester in future labs to do wire maps and so on. If an inexpensive basic cable tester is unavailable, the Fluke (or equivalent) is more than adequate. Advanced cable tests can cost from hundreds to thousands of dollars.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have several basic cable testers available (one for each team of students) or several Fluke Cable meters and various lengths of wire with induced problems. Work in teams of two. The following resources will be required:

- Basic cable tester

- Advanced cable tester (Fluke 620 or equivalent)
- Two lengths of good CAT 5 cable (one crossover and one straight-through, use different colors or labels)
- Two lengths of bad CAT 5 cable (one with a break and one with a short, use different colors or labels)

If you are using a basic cable tester, refer to the instructions from the manufacturer and insert the ends of the cable to be tested into the jacks accordingly. If you are using the Fluke 620, use the following instructions to test the four cables. Insert the RJ-45 from one end of the cable into the UTP/FTP jack on the tester and turn the dial to test. All conductors will be tested to verify they are not broken or shorted.

NOTE:

This test does not verify that the pins are connected correctly from one end to the other.

Notes:

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Step 1 - For each test, insert the cable into the RJ-45 jack(s) of the cable tester and record your results below:

	Color or Cable number?	**Category Type(CAT 3, CAT 5 etc?)**	**Straight-through or crossover?**	**Length of cable**	**Test results**
Cable #1					
Cable #2					
Cable #3					
Cable #4					
Cable #5					

Lab 5.3.2 straight-through Cable

Estimated time: 30 min.

Objectives:

- Build a straight-through Ethernet patch cable to T568-B (OR T568-A) standards for connection from workstation to hub/switch or patch panel to hub/switch.

Background:

In this lab you will learn how to build a Category 5 (CAT 5) Unshielded Twisted Pair (UTP) Ethernet network patch cable (or patch cord) and test it for good connections (continuity) and correct pinouts (correct color of wire on the right pin). This will be a four-pair (eight wires) "straight through" cable which means that the color of wire on pin 1 on one end of the cable will be the same as pin 1 on the other end. Pin 2 will be the same as pin 2 and so on. It will be wired to TIA/EIA-568-B or A standards for 10BASE-T Ethernet which determines what color wire is on each pin. T568-B (also called AT&T specification) is more common, but many installations are also wired to T568-A (also called ISDN).

This patch cable will conform to the structured cabling standards and is considered to be part of the "horizontal" cabling which is limited to 99 meters total between workstation and hub or switch. It can be used in a workstation area to connect the workstation NIC to the wall plate data jack. It can also be used in the wiring closet to connect the patch panel (horizontal cross-connect) to an Ethernet hub or switch. Patch cables are wired straight-through since the cable from the workstation to the hub or switch is normally crossed over automatically at the switch or the hub. Note that the ports on most hubs have an X next to them. This means the send and receive pairs will be crossed when the cabling reaches the switch. The pinouts will be T568-B and all eight conductors (wires) should be terminated with RJ-45 modular connectors (only four of the eight wires are used for 10/100BASE-T Ethernet, all eight are used for 1000BASE-T Ethernet).

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have a spool of Cat 5 Unshielded Twisted Pair (UTP) cable, RJ-45 (8-pin) connectors, an RJ-45 crimping tool and an Ethernet / RJ-45 continuity tester available. Work individually or in teams. The following resources will be required:

- Two to three foot length of Cat 5 cabling (one per person or one per team)
- Four RJ-45 connectors (two extra for spares)
- RJ-45 crimping tools to attach the RJ-45 connectors to the cable ends
- Ethernet cabling continuity tester that can test straight-through or crossover type cables (T568-A or T568-B).
- Wire cutters

Step 1 - Cabling Information.

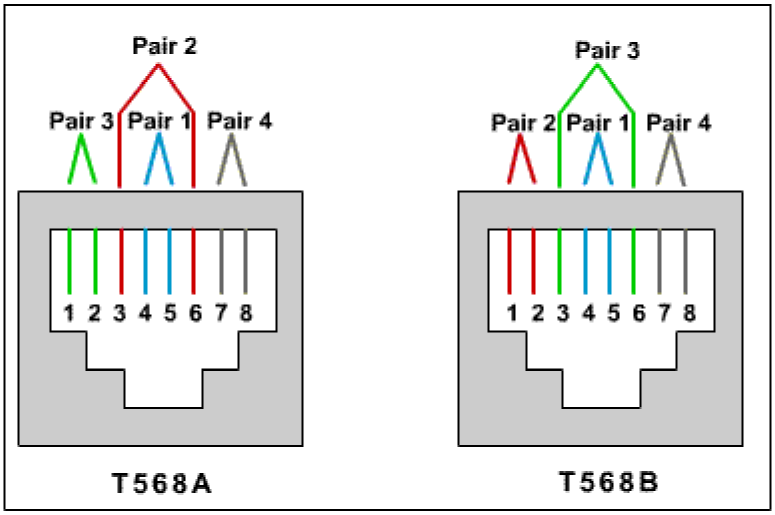
Explanation: Instructions are provided here for building a T568-A or T568-B cable. Either can be used as long as all connections (pinouts) from the workstation to the wiring closet and terminating electronics (hubs or switches) are consistent. If cables are to be built for an existing network it is important to keep the same standard as already exists (either T568-A or B). A patch cable that is wired "straight through" will have the same color of wire on the same pin (1 -- 8) at both ends. A straight through patch cable (T568-A or B) can be used to connect a PC workstation to a wall plate in a work area or it can be used to connect from a patch panel in a wiring closet to a hub or a switch. A PC can also be connected directly to a port on a hub or switch with this cable. If a cable will be used to connect from an "uplink" port on one hub to a "crossover" front port on another hub then a straight through cable should be used

Step 2 - Create a T568-B straight-through patch panel cable.

Task: Use the following tables and diagrams and steps to create a T568-B patch panel cable.
Explanation: Both cable ends should be wired the same when looking at the conductors. Only four wires are used with 10BASE-T or 100BASE-TX Ethernet:

Pin#	Pair#	Function	Wire Color	Used with 10/100 BASE-T Ethernet?	Used with 100 BASE-T4 and 1000 BASE-T Ethernet?
1	2	Transmit	White/Orange	Yes	Yes
2	2	Transmit	Orange/White	Yes	Yes
3	3	Receive	White/Green	Yes	Yes
4	1	Not used	Blue/White	No	Yes
5	1	Not used	White/Blue	No	Yes
6	3	Receive	Green/White	Yes	Yes
7	4	Not used	White/Brown	No	Yes
8	4	Not used	Brown/White	No	Yes

Diagram showing both T568-A and T568-B cabling wire colors



1. Determine the distance between devices, or device and plug, then add at least 12" to it. The maximum length for this cord is 3 m; standard lengths are 6' and 10'.
2. Cut a piece of stranded Cat 5 unshielded twisted-pair cable to the determined length. You will use stranded cable for patch cables because it is more durable when bent repeatedly. Solid wire is fine for cable runs that are punched down into jacks.
3. Strip 2" of jacket off of one end of the cable.
4. Hold the four pairs of twisted cables tightly where jacket was cut away, then reorganize the cable pairs into the order of the 568-B wiring standard. Take care to maintain the twists since this provides noise cancellation. (orange pair, green pair, blue pair, brown pair).
5. Hold the jacket and cable in one hand, untwist a short length of the green and blue pairs, and reorder them to reflect the 568-B wiring color scheme. Untwist and order the rest of the wire pairs according to the color scheme.
6. Flatten, straighten, and line up the wires, then trim them in a straight line to within 1/2" - 3/4" from the edge of the jacket. Be sure not to let go of the jacket and the wires, which are now in order. You should minimize the length of untwisted wires because overly long sections that are near connectors are a primary source of electrical noise.
7. Place an RJ-45 plug on the end of the cable, with the prong on the underside and the orange pair to the left side of the connector.
8. Gently push the plug onto wires until you can see the copper ends of the wires through the end of the plug. Make sure the end of the jacket is inside the plug and all wires are in the correct order. If the jacket is not inside the plug, it will not be properly strain relieved and will eventually cause problems. If everything is correct, crimp the plug hard enough to force the contacts through the insulation on the wires, thus completing the conducting path.
9. Repeat steps 3 through 8 to terminate the other end of the cable, using the same scheme to finish the straight through cable.
10. Test the finished cable and have the instructor check it. How can you tell if your cable is functioning properly?

Lab 5.3.3 Rollover Cable

Estimated time: 30 min.

Objectives:

- Build a rollover cable for connection from a workstation to the console port on a router or switch

Background:

In this lab you learn how to build a Category 5 (CAT 5) Unshielded Twisted Pair (UTP) console rollover cable and test it for good connections (continuity) and correct pinouts (correct wire on the right pin). This will be a four-pair (eight wires) "rollover" cable.

This cable should be approximately 10 feet in length but can be as long as 25 feet. It can be used to connect a workstation or dumb terminal to the console port on the back of a router or Ethernet switch in order to be able to configure the router or switch. This cable uses an asynchronous serial interface to the router or switch (eight data bits, No parity and two Stop bits). Both ends of the cable you build will have RJ-45 connectors on them. One end plugs directly into the RJ-45 console management port on the back of the router or switch and the other end plugs into an RJ-45-to-DB9 terminal adapter. This adapter converts the RJ 45 to a 9-pin female D connector that plugs into the DB9 serial port male adapter on the back of a PC running terminal emulation software such as HyperTerminal. A DB25 terminal adapter is also available to connect with a dumb terminal that has a 25 pin connector.

A rollover cable uses eight pins but is different from the straight-through cable or crossover cable that you will build in other labs. With a rollover cable, pin 1 on one end connects to pin 8 on the other end. Pin 2 connects to pin 7, pin 3 connects to pin 6 and so on. This is why it is referred to as a rollover since the pins on one end are all reversed on the other end as though one end of the cable was just rotated or rolled over.

A flat black or light blue rollover cable comes with each new router or switch along with the terminal adapters for both DB9 and DB25 connections to terminals or PC serial ports. It is approximately 8 feet long. This lab will enable you to build another cable if the one that comes with the router or switch is damaged or lost. It will also allow you to connect to routers or switches from workstations that are greater than 8 feet away by building your own longer cables.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have a spool of Cat 5 Unshielded Twisted Pair (UTP) cable, RJ-45 (eight pin) connectors, an RJ-45 crimping tool and a continuity tester available. Work individually or in teams. The following resources will be required:

- 10 to 20 foot length of Cat 5 cabling (one per person or one per team)
  Four RJ-45 connectors (two extra for spares)
- RJ-45 crimping tools to attach the RJ-45 connectors to the cable end

- An RJ-45 to DB9 female terminal adapter (available from Cisco)
- Cabling continuity tester
- Wire cutters

Step 1 - Review Cable Connections and Pin Locations

Use the table as a reference to answer the questions below and to help you create a rollover console cable.

Questions:

1. Which signal on the Router port (first column of the table) will be used to transmit data to the PC when the PC is first connected and HyperTerminal is started (this is what displays the router prompt on the workstation)?

____

2. Which pin is this connected to on the router end of the RJ-45 cable?

____

3. Which pin is this connected to on the other end of the RJ-45 cable?

____

4. Which pin is this connected to in the DB9 connector?

____

5. Which console device signal does this connect to?

____

6. What would happen if pin 3 on the left cable end were attached to pin 3 as with a straight-through cable?

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<u>Rollover Console Cable Table</u>

A rollover cable is used for connecting from a router or switch console port to a PC workstation running HyperTerminal terminal emulation software. The cable connects to the serial port on the PC using an RJ-45 to DB9 or DB25 Adapter.

Router or switch Console port (DTE)	RJ-45 to RJ-45 Rollover Cable (left	RJ-45 to RJ-45 Rollover Cable (right	RJ-45 to DB9 Adapter	Console Device (PC workstation serial port)

	end)	end)		
Signal	**From RJ-45 Pin No.**	**To RJ-45 Pin No.**	**DB9 Pin No.**	**Signal**
RTS	**1**	**8**	**8**	**CTS**
DTR	**2**	**7**	**6**	**DSR**
TxD	**3**	**6**	**2**	**RxD**
GND	**4**	**5**	**5**	**GND**
GND	**5**	**4**	**5**	**GND**
RxD	**6**	**3**	**3**	**TxD**
DSR	**7**	**2**	**4**	**DTR**
CTS	**8**	**1**	**7**	**RTS**

Signal Legend: RTS = Request To Send, DTR = Data Terminal Ready, TxD = Transmit Data, GND = Ground (One for TxD and one for RxD), RxD = Receive Data, DSR = Data Set Ready, CTS = Clear To Send.

Step 2 - Use the following steps to build the rollover console cable.

1. Determine the distance between devices, then add at least 12" to it. Make your cable about 10 feet unless you are connecting to router or switch from a greater distance. The maximum length for this cable is about 8m (appx 25 feet).
2. Strip 2" of jacket off of one end of the cable.
3. Hold the four pairs of twisted cables tightly where jacket was cut away, then reorganize the cable pairs and wires into the order of the 568-B wiring standard.
4. Flatten, straighten, and line up the wires, then trim them in a straight line to within 1/2" - 3/4" from the edge of the jacket. Be sure not to let go of the jacket and the wires, which are now in order.
5. Place an RJ-45 plug on the end of the cable, with the prong on the underside and the orange pair to the left side of the connector.
6. Gently push the plug onto wires until you can see the copper ends of the wires through the end of the plug. Make sure the end of the jacket is inside the plug and all wires are in the correct order. If the jacket is not inside the plug, it will not be properly strain relieved and will eventually cause problems. If everything is correct, crimp the plug hard enough to force the contacts through the insulation on the wires, thus completing the conducting path.
7. Repeat steps 2 through 6 to terminate the other end of the cable, but reversing every pair of wires as indicated in the table above. (pin 1 to pin 8, pin 2 to pin 7, pin 3 to pin 6 and so on. Alternate Method - Arrange the wires into the order of the 568-B wiring standard. Place a RJ-45 plug on the end with the prong on the top side of the connector. This method will achieve the proper reversing of every pair of wires.
8. Test the finished cable and have the instructor check it. How can you tell if your cable is functioning properly?

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Lab 5.3.4 Crossover Cable

Estimated time: 30 min.

Objectives:

- Build a crossover Ethernet patch cable to T568-B (or T-568-A) standards for connection from workstation to workstation or from switch to switch.

Background:

In this lab you will learn how to build a Category 5 (CAT 5) Unshielded Twisted Pair (UTP) Ethernet crossover network cable and test it for good connections (continuity) and correct pinouts (correct color of wire on the right pin). This will be a four-pair (eight wires) "crossover" cable which means that pairs two and three on one end of the cable will be reversed on the other end. It will be wired to TIA/EIA-568-B and A standards for 10BASE-T Ethernet which determines what color wire is on each pin. The pinouts will be T568-A on one end and T568-B on the other end. All eight conductors (wires) should be terminated with RJ-45 modular connectors.

This patch cable will conform to the structured cabling standards and, if it is used between hubs or switches, is considered to be part of the "vertical" cabling also know as backbone cable. A crossover cable can be used as a backbone cable to connect two or more hubs or switches in a LAN or to connect two isolated workstations to create a mini LAN. This will allow you to connect two workstations together or a server and a workstation without the need for a hub between them. This can be very helpful for training and testing. If you want to connect more than two workstations you will need a hub or a switch.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have a spool of Cat 5 Unshielded Twisted Pair (UTP) cable, RJ-45 (8-pin) connectors, a RJ-45 crimping tool and an Ethernet / RJ-45 continuity tester available. Work individually or in teams. The following resources will be required:

1. Two to three foot length of Cat 5 cabling (one per person or one per team)
2. Four RJ-45 connectors (two extra for spares)
3. RJ-45 crimping tools to attach the RJ-45 connectors to the cable ends
4. Ethernet cabling continuity tester that can test crossover type cables (T568-A to T568-B).
5. Wire cutters

Step 1 - Create a crossover patch panel cable.

Use the following tables and diagrams and steps to create a crossover cable. One end of the cable should be wired to the T568-A standard and the other end to the T568-B standard. This crosses the transmit and receive pairs (2 and 3) to allow communication to take place. Only four wires are used with 10BASE-T or 100BASE-TX Ethernet:

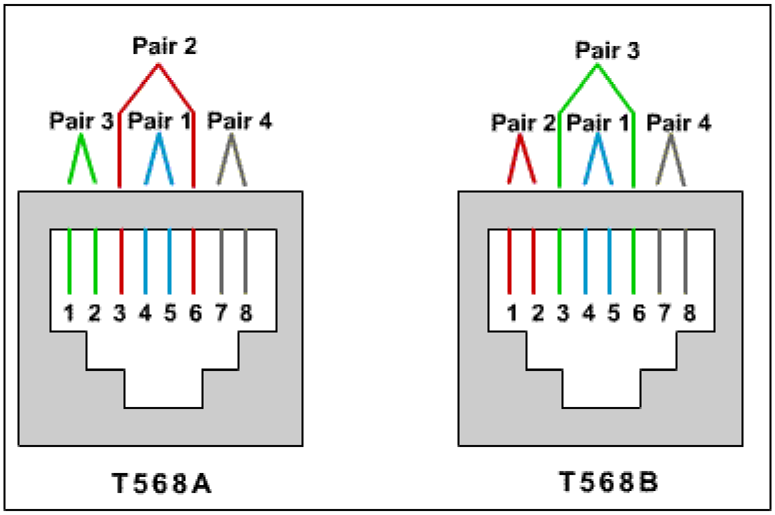
T568-A Cabling

Pin#	Pair#	Function	Wire Color	Used with 10/100 BASE-T Ethernet?	Used with 100 BASE-T4 and 1000 BASE-T Ethernet?
1	3	Transmit	White/Green	Yes	Yes
2	3	Transmit	Green/White	Yes	Yes
3	2	Receive	White/Orange	Yes	Yes
4	1	Not used	Blue/White	No	Yes
5	1	Not used	White/Blue	No	Yes
6	2	Receive	Orange/White	Yes	Yes
7	4	Not used	White/Brown	No	Yes
8	4	Not used	Brown/White	No	Yes

T568-B Cabling

Pin#	Pair#	Function	Wire Color	Used with 10/100 BASE-T Ethernet?	Used with 100 BASE-T4 and 1000 BASE-T Ethernet?
1	2	Transmit	White/Orange	Yes	Yes
2	2	Transmit	Orange/White	Yes	Yes
3	3	Receive	White/Green	Yes	Yes
4	1	Not used	Blue/White	No	Yes
5	1	Not used	White/Blue	No	Yes
6	3	Receive	Green/White	Yes	Yes
7	4	Not used	White/Brown	No	Yes
8	4	Not used	Brown/White	No	Yes

Diagram showing both T568-A and T568-B cabling wire colors



1. Determine the distance between devices, or device and plug, then add at least 12" to it. The maximum length for this cord is 3 m; standard lengths are 6' and 10'.
2. Cut a piece of stranded Cat 5 unshielded twisted pair cable to the determined length. You will use stranded cable for patch cables because it is more durable when bent repeatedly. Solid wire is fine for cable runs that are punched down into jacks.
3. Strip 2" of jacket off one end of the cable.
4. Hold the four pairs of twisted cables tightly where jacket was cut away, then reorganize the cable pairs into the order of the 568-B wiring standard. Take care to maintain the twists since this provides noise cancellation. (orange pair, green pair, blue pair, brown pair)
5. Hold the jacket and cable in one hand, untwist a short length of the green and blue pairs, and reorder them to reflect the 568-B wiring color scheme. Untwist and order the rest of the wire pairs according to the color scheme.
6. Flatten, straighten, and line up the wires, then trim them in a straight line to within 1/2" - 3/4" from the edge of the jacket. Be sure not to let go of the jacket and the wires, which are now in order. You should minimize the length of untwisted wires because overly long sections that are near connectors are a primary source of electrical noise.
7. Place an RJ-45 plug on the end of the cable, with the prong on the underside and the orange (green on the 586-A end) pair to the left side of the connector.
8. Gently push the plug onto wires until you can see the copper ends of the wires through the end of the plug. Make sure the end of the jacket is inside the plug and all wires are in the correct order. If the jacket is not inside the plug, it will not be properly strain relieved and will eventually cause problems. If everything is correct, crimp the plug hard enough to force the contacts through the insulation on the wires, thus completing the conducting path.
9. Repeat steps 3 through 8 to terminate the other end of the cable, using the 568-A scheme to finish the crossover cable.
10. Test the finished cable and have the instructor check it. How can you tell if your cable is functioning properly?

Lab 5.3.5 Cable Tester - Wire Map

Estimated time: 45 min.

Objectives:

- Demonstrate skill with a cable tester more advanced than a simple continuity/pin-out tester
- Use the wire mapping features of the tester to check for opens and shorts with UTP cable
- Perform wire mapping on cables, detecting faults that are not detectable with simple continuity measuring devices such as crossed and split pairs

Background:

In this lab you will learn the wire mapping features of the Fluke 620 LAN CableMeter (or its equivalent). Wire maps can be very helpful in troubleshooting cabling problems with UTP cable. Wire maps are not used with coaxial cable since there is only one wired and no map is needed. A wire map allows the network technician to verify which pins on one end of the cable are connected to which pins on the other end. With an understanding of the proper wiring connections, you can determine when a cable is wired improperly, depending on its intended use. You will learn how to use a cable tester to check for the proper installation of Unshielded Twisted Pair (UTP) Category 5 (CAT 5) according to TIA/EIA-568 cabling standards in an Ethernet network. You will test different cables using all four pairs to determine some problems that can occur from incorrect cabling installation and termination.

The cabling infrastructure (or cable plant) in a building is expected to last at least 10 years. Cabling related problems are one of the most common causes of network failure. The quality of cabling components used, the routing and installation of the cable and quality of the connector terminations will be the main factors in determining how trouble-free the cabling will be.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have several correctly wired CAT 5 cables (both straight-through and crossover) to test. There should also be several CAT 5 cables created with problems such as poor connections and split pairs to test. Cables should be numbered to simplify the testing process and to maintain consistency. A cable tester should be available that can test at least continuity, cable length and wire map. Work individually or in teams. The following resources will be required:

- CAT 5 straight-wired cables of different colors.
- CAT 5 crossover cable (T568A on one end and T568B on the other)
- CAT 5 straight-through cables with open wire connections in the middle or one or more conductors shorted at one end of different colors and different lengths.
- CAT 5 straight-through cable with a split pair miswire.
- Cable Tester (Fluke 620 LAN CableMeter or similar) to test cable length, continuity, wire map

Related Research websites:

- http://www.fluke.com/

Step 1 - Set the Advanced Cable Tester for the Desired Cable.

These instructions pertain to the Fluke 620 LAN CableMeter. Turn the rotary switch selector on the tester to the WIRE MAP position. Press the SETUP button to enter the setup mode and observe the LCD screen on the tester. The first option should be CABLE: Press the UP or DOWN buttons until the desired cable type of UTP is selected. Press ENTER to accept that setting and go to the next one. Continue pressing the UP/DOWN arrows and pressing ENTER until the tester is set to the following cabling characteristics.

Tester Option	Desired Setting
CABLE:	UTP
WIRING:	10BASE-T or EIA/TIA 4PR
CATEGORY:	CAT 5
WIRE SIZE	AWG 24
CAL to CABLE?	NO
BEEPING:	ON or OFF
LCD CONTRAST	From 1 thru 10 (brightest)

Step 2 - Setup the Cable to be Tested

For each cable to be tested use the following procedure, place the near end of the cable into the RJ-45 jack labeled UTP/FTP on the tester. Place the RJ-45-to-RJ-45 female coupler on the far end of the cable and then insert the Cable Identifier into the other side of the coupler. The coupler and the cable identifier are accessories that come with the Fluke 620 LAN CableMeter.

Step 3 - Perform Wire Map Testing

Using the tester Wire Map function and a Cable ID Unit, you can determine the wiring of both the near and far end of the cable. The top set of numbers displayed on the LCD screen is the near end and the bottom set is the far end. Perform a Wire Map test on each of the cables provided and fill in the following table based on the result for each CAT 5 cable tested. For each cable, write down the number and color, whether the cable is straight-through or crossover, the tester screen test results and what you think the problem is.

Cable No.	**Cable Color**	**How cable is wired** (straight-through or crossover)	**Tester Displayed Test Results** (Note: refer to the Fluke manual for detailed description of test	**Problem Description**

			results for wire map)	
1			Top: Bot:	
2			Top: Bot:	
3			Top: Bot:	
4			Top: Bot:	
5			Top: Bot:	

Lab 5.3.6 straight-through Cable

Estimated time: 45 min.

Objectives:

- Demonstrate skill with a cable tester more advanced than a simple continuity/pin-out tester
- Use the Test feature of the tester to check for opens and shorts with coax and UTP cable
- Understand the use of the Cable ID feature

Background:

In this lab, you will learn the Cable Test - Pass / Fail features of the Fluke 620 LAN CableMeter (or its equivalent). Basic cable tests can be very helpful in troubleshooting cabling problems with UTP and coaxial cable. You will learn how to use a cable tester to check for the proper installation of Unshielded Twisted Pair (UTP) and Coaxial (Thinnet) for an Ethernet network. You will test different cables to determine some problems that can occur from incorrect cabling installation and termination.

The cabling infrastructure (or cable plant) in a building is expected to last at least 10 years. Cabling related problems are one of the most common causes of network failure. The quality of cabling components used, the routing and installation of the cable and quality of the connector terminations will be the main factors in determining how trouble-free the cabling will be.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have several correctly wired CAT 5 cables (both straight-through and crossover) to test. There should also be several CAT 5 cables created with problems and a coaxial cable to test. Cables should be numbered to simplify the testing process and to maintain consistency. A cable tester should be available that can do basic cable test for UTP and coax. Work individually or in teams. The following resources will be required:

- CAT 5 straight-through and crossover wired cables of different colors (some good and some bad)
- CAT 5 straight-through and crossover wired cables with open wire connections in the middle or one or more conductors shorted at one end of different colors and different lengths
- Coax cable with a short in it
- Cable Tester (Fluke 620 LAN CableMeter or similar) to test cable length, continuity, wire map

Related Research websites:

Here are several websites where you can get additional information on cabling standards:

http://www.fluke.com/

Step 1 - Set the Advanced Cable Tester for the Desired Cable (UTP or COAX).

These instructions pertain to the Fluke 620 LAN CableMeter. Turn the rotary switch selector on the tester to the TEST position. Press the SETUP button to enter the setup mode and observe the LCD screen on the tester. The first option should be CABLE: Press the UP or DOWN buttons until the desired cable type of UTP or COAX (thinnet) is selected. Press ENTER to accept that setting and go to the next one. Continue pressing the UP/DOWN arrows and pressing ENTER until the tester is set to the following cabling characteristics depending on the type of cable you will be testing.

Tester Option	**Desired Setting - UTP**	**Desired Setting - COAX**
CABLE:	UTP	COAX
WIRING:	10BASE-T or EIA/TIA 4PR	10BASE2 or RG58 (thinnet)
CATEGORY:	CAT 5	N/A
WIRE SIZE	AWG 24	N/A
CAL to CABLE?	NO	NO
BEEPING:	ON or OFF	ON or OFF
LCD CONTRAST	From 1 thru 10 (brightest)	From 1 thru 10 (brightest)

Step 2 - Setup the Cable to be Tested (UTP or COAX)

For each cable to be tested use the following procedure, place the near end of the cable into the RJ-45 jack labeled UTP/FTP on the tester. Place the RJ-45-to-RJ-45 female coupler on the far end of the cable and then insert the Cable Identifier into the other side of the coupler. The coupler and the cable identifier are accessories that come with the Fluke 620 LAN CableMeter. Multiple Cable Id's with different numbers can be purchased to help in identifying which cable you are working with. For coax cables, insert one end of the BNC connector into the jack labeled COAX on the tester. Coax cables should not have a terminating resistor.

Step 3 - Perform Basic Cable Test - Pass/Fail Function

Using the tester's Test function and a Cable ID Unit (for UTP), you can determine the functionality of the cable. Perform a basic cable test on each of the cables provided and fill in the following table based on the result for each cable tested. For each cable, write down the number and color, whether the cable is straight-through, crossover or coaxial. Include also the tester screen test results and what you think the problem is. The Cable ID can be used to identify a particular cable by moving it to another cable.

Cable No.	**Cable Color**	**How cable is wired** (UTP or coax)	**Tester Displayed Test Results** (Note: refer to the Fluke manual for detailed description of test results)	**Problem Description**

1				
2				
3				
4				

Lab 5.3.7 Cable Tester - Length

Estimated time: 45 min.

Objectives:

- Demonstrate skill with a cable tester more advanced than a simple continuity/pin-out tester
- Use the Length features of the tester to check for opens and shorts with coax and UTP cable

Background:

In this lab, you will learn the Cable Length feature of the Fluke 620 LAN CableMeter (or its equivalent). Cable length tests can be very helpful in troubleshooting cabling problems with UTP and coaxial cable. You will learn how to use a cable tester to check the length of Ethernet cabling to verify that it is within the standards specified and that the wires inside are the same length (for UTP). You will test different cables including UTP and Coax to determine their length.

The Cabling infrastructure (or cable plant) in a building is expected to last at least 10 years. Cabling related problems are one of the most common causes of network failure. The quality of cabling components used, the routing and installation of the cable and quality of the connector terminations will be the main factors in determining how trouble-free the cabling will be.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have several correctly wired CAT 5 cables (both straight-through and crossover) and several Coaxial (thinnet) cables to test. Cables should be numbered to simplify the testing process and to maintain consistency. A cable tester should be available that can do cable length tests for UTP and coax. Work individually or in teams. The following resources will be required:

- CAT 5 straight or crossover cables of different colors. (some good and some bad)
- Coax (thinnet) cables of different lengths
- Cable Tester (Fluke 620 LAN CableMeter or similar) to test cable length

Related Research websites:

Here are several websites where you can get additional information on cabling standards:

http://www.fluke.com/

Step 1 - Set the Advanced Cable Tester for the Desired Cable (UTP or COAX)

These instructions pertain to the Fluke 620 LAN CableMeter. Turn the rotary switch selector on the tester to the LENGTH position. Press the SETUP button to

enter the setup mode and observe the LCD screen on the tester. The first option should be CABLE: Press the UP or DOWN buttons until the desired cable type of UTP or COAX (thinnet) is selected. Press ENTER to accept that setting and go to the next one. Continue pressing the UP/DOWN arrows and pressing ENTER until the tester is set to the following cabling characteristics depending on the type of cable you will be testing.

Tester Option	**Desired Setting - UTP**	**Desired Setting - COAX**
CABLE:	UTP	COAX
WIRING:	10BASE-T or EIA/TIA 4PR	10BASE2 or RG58 (thinnet)
CATEGORY:	CAT 5	N/A
WIRE SIZE	AWG 24	N/A
CAL to CABLE?	NO	NO
BEEPING:	ON or OFF	ON or OFF
LCD CONTRAST	From 1 thru 10 (brightest)	From 1 thru 10 (brightest)

Step 2 - Setup the Cable to be Tested (UTP or COAX)

For each cable to be tested use the following procedure, place the near end of the cable into the RJ-45 jack labeled UTP/FTP on the tester. Place the RJ-45-RJ-45 female coupler on the far end of the cable and then insert the Cable Identifier into the other side of the coupler. The coupler and the cable identifier are accessories that come with the Fluke 620 LAN CableMeter. For coax cables, insert one end of the BNC connector into the jack labeled COAX on the tester. Coax cables should not be terminated. If tested with a terminating resistor (50W), the display will be the resistance of the cable plus the terminating resistor.

Step 3 - Perform Cable Length Test Function

Using the tester Test function and a Cable ID Unit (for UTP), you can determine the functionality of the cable. Perform a Basic cable Test on each of the cables provided and fill in the following table based on the result for each CAT 5 cable tested. For each cable, write down the number and color, whether the cable is straight-through or crossover or coaxial, the tester screen test results and what you think the problem is. For UTP cables, press the down arrow or up arrow to see all pairs.

Cable No.	**Cable Color**	**How cable is wired** (UTP or coax)	**Tester Displayed Test Results** (Note: refer to the Fluke manual for detailed description of test results)	**Problem**
1				
2				
3				
4				

Lab 7.6.2 Network Discovery

Estimated time: 20 min.

Objectives:

- Use Network Inspector (or equivalent) Software to Perform Network Discovery.

Background:

One of the most powerful tools for troubleshooting computer networks is Network Management software. There are many fine programs for performing various network discovery, monitoring, and analysis tasks. In this lab you will explore a basic network management application, Fluke Network Inspector 3.0 (or equivalent). You will use the Network Inspector to perform a process called network discovery. As the number of computers, servers, printers, switches, and routers on a network grows, it can be difficult to keep track of all of the relevant characteristics of the devices. Such information as MAC addresses, IP addresses, and topologies are crucial for troubleshooting a network. You will use Network Inspector to perform a network discovery on an Ethernet 10BASE-T (or 100BASE-TX) network.

Tools / Preparation:

Each PC must be running Windows (95, 98, NT, 2000), Microsoft TCP/IP stack, and Winsock 2.0. Fluke Network Inspector 3.0 (or equivalent) must be installed on each PC. During the installation of the software you must specify which network adapter (NIC, dialup, and so on) you wish to monitor. The NIC which attaches the PC to an Ethernet should be specified. The PCs should be on either a 10BASE-T or 100BASE-TX Ethernet network which preferably includes servers, switches, routers, and printers (this will make the network discovery more interesting). The following resources will be required:

- PC with Windows 95 or better, Microsoft TCP/IP stack, and Winsock 2.0.
- Fluke Network Inspector 3.0 Software

Worksheet

1. If you have not done so already, install Network Inspector software (the "Agent" and the "Console") on your PC. How will you know if this step was done correctly?

   ____

2. Make sure you are connected to a working Ethernet network. What are some signs that you are on the network?

   ____

3. Open Fluke Network Inspector Agent. You will be prompted to do something. What are you prompted to do and why do you suppose you must do this?

___

4. Now the Agent will prompt you with a status screen. Click on the tabs and write down the major categories of things you can control about the Agent. Under the database/address tab, click on "overwrite" so that the new data you are controlling will be stored in the database. Click Apply.

___

5. Start the Agent. What is the status shown? What does the status change to after a few minutes? What do you suppose is happening? Minimize the Agent.

___

6. Open Fluke Network Inspector Console. What do you see?

___

7. Allow the agent to run for a few minutes. What do you see?

___

8. Stop the Agent and Minimize the Agent screen. What significant information about the network have you obtained? Write down a few complete lines of the database.

___

___

9. In the left hand control panel, click on each of the "Devices" and explain briefly what they are: "Fluke Tools", "Key Devices", "Utilization Sources", " SNMP Agents", "Services", "Routers", "Switches", "Printers", and "Hosts".

___

___

___

10. Start another capture to examine the network you are on.

Reflection:

Imagine you have earned your CCNA and are working in a medium size company. Write in your journal what value you see in using Network Management software.

____

____

____

Lab 7.6.3 Network Discovery

Estimated time: 20 min.

Objectives:

- Use Network Inspector (or equivalent) software problem logging function to monitor network management information such as errors, warnings and changes.

Background:

Network Management is an important part of a networking professional's responsibilities. One of the most common network management tasks is keeping track of IP addresses. You have been reading about IP addresses and subnets. The Network Analysis software will allow you to get the "big picture" of how IP addresses are assigned on your networks and subnetworks. It will also allow you to access detailed information from the problem log for errors (such as incorrect subnet mask), warnings (such as incorrect IP address), and changes (such as IP address change).

Tools / Preparation:

Each PC must be running Windows (95, 98, NT, 2000), Microsoft TCP/IP stack, and Winsock 2.0. Fluke Network Inspector 3.0 (or equivalent) must be installed on each PC. During the installation of the software you must specify which network adapter (NIC, dialup, and so on) you wish to monitor - specify the NIC which attaches the PC to an Ethernet. The PCs should be on either a 10BASE-T or 100BASE-TX Ethernet network which preferably includes servers, switches, routers, and printers (this will make the network discovery more interesting). The following resources will be required:

- PC with Windows 95 or better, Microsoft TCP/IP stack, and Winsock 2.0.
- Fluke Network Inspector 3.0 Software

Worksheet

1. Make sure you are connected to the network. How can you verify this?

   ____

2. Log into network inspector agent, set database tab to overwrite, and start the agent running.
3. Open network inspector console, watch until network discovery appears to have stopped. Stop agent.
4. Go to Help --> About the problem log and troubleshooting problems --> errors, warnings and changes that can be discovered - does a list appear?

   ____

5. Review the list. Choose three errors, three warnings, and three changes that you believe are important and describe them in your own words.

6. Return to database view. Are there any errors, warnings, and changes that have appeared? If you instructor tells you so, try starting and stopping the agent again, rediscovering the network, and seeing if the instructor has caused any errors, warnings, or changes. Note these changes in your journal.

7. Can you draw a topology of the network based on the IP addresses and subnetwork information obtained? Go ahead and try.

Reflection:

Imagine you are a network administrator. Describe how this software would be useful to you.

Lab 7.6.4 Protocol Inspector Frame Stats

Estimated time: 35 min.

Objectives:

- Use Protocol Inspector (or equivalent) software to examine some simple network utilization and frame statistics, in order to make more real the concept of frame flow as the heartbeat of the LAN

Background:

Protocol analysis software, often called protocol "sniffers", allow an in depth view of the amazing diversity of network processes. Protocol analysis software often lets you study protocols at various layers of the OSI model, especially layers 2, 3, 4, 5, and 7. In this lab you will focus on Layer 2 information. You have been studying about frames, the Layer 2 protocol data unit (PDU). Frames may seem like an abstract thing, hard to imagine, but they are constantly being sent and received by your PC on a network. One feature of protocol analysis software is the ability to gather statistics about frames on the "wire" in real-time, so you can see some of the frame processes occurring. This is one indication of the health of a network, and helps in troubleshooting network problems. Most protocol analyzers can capture frames to and from a host based on MAC address, IP address and the type of traffic to be monitored. Be warned that this is an amazingly powerful piece of software with many features, so you will learn them in small labs.

Tools / Preparation:

Each PC must be running Windows (95, 98, NT, 2000), Microsoft TCP/IP stack, and Winsock 2.0. Fluke Protocol Inspector 3.0 (or equivalent) must be installed on each PC. During the installation of the software you must specify which network adapter (NIC, dialup, and so on) you wish to monitor. The NIC which attaches the PCs to an Ethernet should be specified. The PCs should be on either a 10BASE-T or 100BASE-TX Ethernet network which preferably includes servers, switches, routers, and printers and a connection to a web server, or preferably the Internet, (this will make the protocol analysis more interesting). The following resources will be required:

1. PC with Windows 95 or better, Microsoft TCP/IP stack, and Winsock 2.0.
2. Fluke Protocol Inspector 3.0 Software

Worksheet

1. Make sure the PC is connected to your LAN (local area network), which preferably is connected to the Internet. What are some ways to determine if your PC is connected to the LAN?

   ____

2. Install the protocol analysis software onto your computer (unless you have already done so). For Protocol Inspector, you must be sure that you have installed the correct NDIS 802.3 module as a Resource in Protocol

Inspector. You will probably need to see several NDIS 802.3 modules as resources, corresponding to different installed adapters on your PC. The Protocol Inspector can only look at one of these adapters at a time, which you must choose. Open the Protocol Inspector program. Do you see multiple adapters in the resource window? (Your instructor may need to specify which one. Note that if you are doing captures and you see no traffic whatsoever, you are probably looking at the wrong resource).

____

3. Choose the correct module with a double click. Describe the two graphs and the six tabs that appear. Write down and explain everything that appears in the "Description" tab.

____

4. Click the start button (first line of icons, third icon from the left) and see if the utilization graph increases above zero (displayed as blue sections on the graph). This indicates network traffic (perhaps switch or router or DNS updates). If after about twenty seconds, you do not see anything, click the stop button. You are about to start our own traffic.

____

5. In another window, open your email program and prepare a to send a simple email to yourself. But do not send it yet.

____

6. Click the start button in Protocol Inspector. Now send the email message and watch the utilization graph as your email is transmitted and then received. Check your email until you get the second blue "bump" indicating receipt of the email, then click the stop icon. If your network is such that the delay for receipt of emails is too long for class time, just watching the transmitted email is fine.

____

7. Check the RX tab. Look at the MAC counters column. What types of frames were received? What does each type mean? Look at the errors column (seven are listed). Imagine what the different types of frame errors are, and put, in your own words, what you think they mean. Frame types include broadcast (to all MAC addresses), multicast (to a group of MAC addresses), or unicast (to one MAC address).

____

____

8. At the top left of the window there should be two lines of icons. On the second line of icons, sixth from the left, is the "Detail View" Icon. Click on it and describe what happens.

9. From detail view, stop the capture. On the first line of icons, select the yellow "file cabinet" eighth from the left "Capture View". What happens?

10. Take a view, scrolling down looking at all the frames and all of the protocols involved in a simple email.

11. Now try out the other views: MAC statistics, Frame Size Distribution Monitor, Protocol statistics, Network Layer Host Table, Application Layer Host Table, Host Matrix, Network Layer Matrix. Comment on each.

Reflection:

1. Imagine you have earned your CCNA and are working in a medium size company. Write in your journal what value you see in using Protocol analyzer software.

2. Does the number of protocol frames for even a simple email request surprise you? Why or why not?

3. Did this lab change the way you view the functioning of computer networks? Explain.

Lab 9.2.12 RJ-45 Jack Outlet Install

Estimated time: 45 min.

Objectives:

- Learn the correct process for terminating (punching-down) a RJ-45 jack
- Learn the correct procedure for installing the jack in a wall plate

Background:

In this lab, you will learn to wire an RJ-45 data jack for installation in a wall plate using a punch-down tool. These skills are useful when you must install a small amount of cabling in an office or residence. A punch tool is a device that uses spring-loaded action to push wires between metal pins, while at the same time, skinning the sheath away from the wire. This ensures that the wire makes a good electrical connection with the pins inside the jack. The punch tool also cuts off any extra wire.

You will work with CAT 5 cabling and CAT 5 rated T568-B jacks. A CAT 5 straight-wired patch cable with an RJ-45 connector will normally plug into this data jack (or outlet) to connect a PC in a work area to the network. It is important that you use CAT 5 rated jacks and patch panels with CAT 5 cabling in order to support higher speed versions of Ethernet such as Fast Ethernet which is 100Mbps. The process of punching down wires into a data jack in an office area is the same as punching them down in a patch panel in a wiring closet such as a Main Distribution Facility (MDF) or Intermediate Distribution Facility (IDF).

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have a spool of Cat 5 Unshielded Twisted Pair (UTP) cable, several RJ-45 data jacks, a 110 Punch down tool and an Ethernet / RJ-45 continuity tester available. Work individually or in teams. The following resources will be required:

- Two to Three foot length of CAT 5 cabling (one per person or one per team)
- Two CAT 5 RJ-45 data jacks (one extra for spare) -- If RJ-45 data jacks are installed on both ends of the cable, the installation can be tested by inserting cable with RJ 45 connectors and a simple cable continuity tester
- CAT 5 Wall Plate
- 110 type punch down tool
- Wire cutters

Worksheet

Use the following procedure and diagram below to punch down the wires into the RJ-45 jack and install the jack into the wall plate:

Step 1 - Remove jacket 1" from the end of the cable.

Step 2 - Position wires in the proper channels on the jack, according to the color chart below.

Step 3 - Use the 110 punch-down tool to push conductors into the channels. Make sure that you position the cut side of the punch-down tool so that it faces the outside of the jack, or you will cut the wire you are trying to punch-down. If any wire remains attached, after you have used the punch tool, simply twist the ends gently to remove them, then, place the clips on the jack, and tighten them.

NOTE:

If you tilt the handle of the punch tool a little to the outside, it will cut better.

NOTE:

Make sure that no more than .5" of untwisted wire is between the end of the cable jacket and the channels on the jack.

Step 4 - Snap the jack into its faceplate by pushing it in from the back side. Make sure, when you do this, that the jack is right-side up (clip faces down when wall plate is mounted).

Step 5 - Use the screws to attach the faceplate to either the box, or to the bracket. If you have surface-mounted the box, keep in mind that it may hold a 1'-2' of excess cable. Then you need to either slide the cable through its tie-wraps, or pull back the raceway that covers it, in order to push the rest of the excess cable back into the wall. If you have flush-mounted the jack, all you need to do is push the excess cable back into the wall.

Category 5 568-B jack wiring color scheme

Hold the jack with the 8-pin jack receptacle (the part the RJ-45 connector goes into) facing up or away from you while looking at the wire channels or slots. There should be four wire channels on each side.

8-pin receptacle

White Green	**White Blue**
Green	**Blue**
White Brown	**White Orange**
Brown	**Orange**

Lab 9.5.1 Demo Cable Installation

Estimated time: 30 min.

Objectives:

- To learn three crucial cable installation skills. They are stringing, running, and mounting Cat 5 cable.

Background:

How you do this lab depends on your instructor's choice of project. You may simply string, run, and mount some cable temporarily for practice. Or you may be actually wiring some or part of your lab. Or you may be doing your structured cabling project, installing networks in some other part of the school or some small business. Regardless of where you are doing your project, you should follow the same professional standards. These were described in Learning Objective 9.4. Assume that one end of your cable run will terminate, via punchdown, in a RJ-45 jack. Assume the other end of your cable run will terminate, via punchdown, in an RJ-45 patch panel. Assume you will be placing the cable in raceways, in ceilings, around obstructions -- various conditions you will likely encounter.

Tools / Preparation:

Basic materials include spools of Cat 5 cable, wire cutter/strippers, punchdown tools, raceway, various mounting consumables like cable ties, cable label, surface mounts, RJ-45 jacks and outlets, rack mounted patch panels, a mock wall, fish tape, telepole, safety goggles, and a ladder. The actual complete list and quantity of materials depends heavily on your actual project. Use the Cost Calculator, available on the Community Server, for a complete lab list and estimated quantities and costs. In other words, actual tools and preparation depend heavily on local conditions and resources. The following resources will be required:

Equipment / Tools

- Wire cutter / strippers
- Fish tape
- Telepole
- Safety goggles
- Ladder
- Punchdown tools

Consumables

- Cat 5 cable
- Raceway
- Cable ties
- Cable label
- Surface mounts
- RJ-45 jacks and outlets
- Rack mounted patch panels

- Mock wall (2x4 with drywall)

Worksheet

Before starting the lab, you and your group should plan your cable run. Walk from where the RJ-45 jack and outlet will be to where the patch panel will be. Look for hazards, obstructions, light fixtures, difficult to reach places, places where cable and raceway will be difficult to mount. Prepare a plan, which includes a diagram of your entire run, the total lengths of cable and raceway you will need, and how you plan to actually install the cable (for example, will you need a ladder to reach a high point in the room?). Once your plan is approved by your instructor, then follow the procedures your instructor has described for you and your team to demonstrate the following procedures/techniques:

1. Fish cable from above.
2. Fish cable from below.
3. String cable through a dropped ceiling space.
4. Wall mount cable by using tie-wraps.
5. Wall mount cable by using decorative raceway.
6. Wall mount cable by using gutter.
7. Mount cable by using a ladder rack.
8. String cable by using a telepole.
9. String cable by using fish tape.
10. String cable using pull string.

Lab 9.7.13 Demo Cable Testing

Estimated time: 30 min.

Objectives:

- Use the Fluke 620 (or equivalent) to perform cable verification experiments on newly installed cable runs

Background:

In lab 9.5.1, you were supposed to do a cable installation. As part of that lab, or as part of a project, you should complete the cable run installation by punching down into an RJ-45 jack on one end and a patch panel on the other. In this lab you are called upon to test this cable run. There are a wide variety of tests and a wide variety of equipment that you could use. In this lab you will learn two techniques, one using a simple cable continuity meter and the other using a more sophisticated cable test meter.

Students should demonstrate the ability to use simple continuity-level cable testers. Instructors should at least demonstrate cable testing to the level of a Fluke 620 CableMeter or equivalent. If more Fluke meters (or equivalent) are available, then training all students on these meters will give them enhanced professional skills. If available (perhaps on loan from your regional academy or a local cable installation company), demonstrate the use of the higher end cable testers -- they are truly remarkable devices which measure many of the cable parameters discussed throughout the curriculum.

Tools / Preparation:

You should be familiar with the use of the Fluke 620 and basic cable testers from the Chapter 5 labs on media. The following resources will be required:

- One completely installed but untested cable run (RJ-45 wall jack to cable to patch panel) per student group
- Fluke 620 CableMeter or equivalent
- Common RJ-45 cable continuity meter
- Journals
- Tools and materials for lab 9.5.1 if the cable run fails the test and must be redone
- High-end Cable Testers (attenuation, NEXT, FEXT) if one can be borrowed from a local company or regional academy

Worksheet

You should be able to take the cable run created in Lab 9.5.1 and test it. Your instructor will demonstrate some of the tests that can be performed with a cable tester. In some instances, the tests will indicate that problems exist. You will be asked to outline how you would determine what the problem is, and describe how you would fix it.

- Complete a Cable Run:

- Use the Fluke 620 Meter on Wire Map to test the installation:
- Identify any faults at near end, along the cable, or far end.
- Correct the faults:
- Retest until the cable run passes on the Fluke Meter:
- Label the Cable Run (alphanumeric identification) as passed and record in your journal.
- (optional) Using the continuity meter, test two straight through patch cords -- one can be short, but the other must make up the entire rest of the distance from jack to patch panel. Test both patch cables on the continuity tester:
- (optional) Connect both cables to the continuity tester. If all of the light pairs (1 to 1, 2 to 2, 3 to 3, and so on up to 8 to 8) light up, you have demonstrated at least the continuity.
- (optional) Perform high-end tests on the cable run with more expensive test equipment.

Lab 10.4.1 IP Addressing Overview

Estimated time: 30 min.

Objectives:

This lab will focus on your ability to accomplish the following tasks:

- Name the five different classes of IP addresses
- Describe the characteristics and use of the different IP address classes
- Identify the class of an IP address based on the network number
- Determine which part (octets) of an IP address is the network ID and which part is the host ID
- Identify valid and invalid IP host addresses based on the rules of IP addressing
- Define the range of addresses and default subnet mask for each class

Background:

This lab will help you develop an understanding of IP addresses and how TCP/IP networks operate. IP addresses are used to uniquely identify individual TCP/IP networks and hosts (computers and printers) on networks in order for devices to communicate. Workstations and servers on a TCP/IP network are called "HOSTS" and each will have a unique IP address which is referred to as its "HOST" address. TCP/IP is the most widely used protocol in the world. The Internet or World Wide Web uses only IP addressing. In order for a host to access the Internet, it must have an IP address.

In its basic form, the IP address has two parts. They are a Network Address portion and a Host Address portion. The network portion of the IP address is assigned to a company or organization by the Internet Network Information Center (InterNIC). Routers use the IP address to move data packets between networks. IP Addresses are 32 bits long (with current version IPv4) and are divided into 4 octets of 8 bits each. They operate at the network layer, Layer 3 of the OSI model, (the Internetwork Layer of the TCP/IP model) and are assigned statically (manually) by a network administrator or dynamically (automatically) by a Dynamic Host Configuration Protocol (DHCP) Server. The IP address of a workstation (host) is a "logical address" meaning it can be changed. The MAC address of the workstation is a 48-bit "physical address" which is burned into the NIC and cannot change unless the NIC is replaced. The combination of the logical IP address and the physical MAC address help route packets to their proper destination.

There are five different classes of IP addresses and depending on the class, the network and host part of the address will use a different number of bits. In this lab you will work with the different classes of IP addresses and become familiar with the characteristics of each. The understanding of IP addresses is critical to your understanding of TCP/IP and Internetworks in general.

Tools / Preparation:

This is primarily a written lab exercise but you may want to use Control Panel / Network to review some real network IP addresses. The following resources will be required:

- PC workstation with Windows operating system (Win 95, 98, NT, or 2000) installed on PC and access to the Windows Calculator.

Notes:

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Step 1 - Review IP Address classes and Their Characteristics.

Explanation: There are five classes of IP addresses (A through E). Only the first three classes are used commercially. We will discuss a class A network address in the table to get started. The first column is the class of IP address. The second column is the first octet which must fall within the range shown for a given class of address. The class A address must start with a number between 1 and 126. The first bit of a class A address is always a zero meaning the High Order Bit (HOB) or the 128 bit cannot be used. 127 is reserved for loop back testing. The first octet alone defines the network ID for a class A network address. The default subnet mask uses all binary ones (decimal 255) to mask the first 8 bits of the class A address. The default subnet mask helps routers and hosts determine if the destination host is on this network or another one. Since there are only 126 class A networks, the remaining 24 bits (3 octets) can be used for hosts. Each class A network can have 2^24 power (2 to the 24th power) or over 16 million hosts. It is common to subdivide the network into smaller groupings called subnets using a custom subnet mask which will be discussed in the next lab.

The network or host portion of the address cannot be all ones or all zeros. As an example, the class A address of 118.0.0.5 is a valid IP address since the network portion (first eight bits equal to 118) is not all zeros and the host portion (the last 24 bits) is not all zeros or all ones. If the host portion were all zeros it would be the network address itself. If the host portion were all 1s it would be a broadcast for the network address. The value of any octet can never be greater than decimal 255 or binary 11111111.

Cls	**1st Octet Decimal Range**	**1st Octet High Order Bits**	**Network / Host ID (N=Network, H=Host)**	**Default Subnet Mask**	**Number of Networks**	**Hosts per Network** (usable addresses)
A	1 - 126*	0	N.H.H.H	255.0.0.0	126 (2^7 - 2)	16,777,214 (2^{24} - 2)
B	128 - 191	1 0	N.N.H.H	255.255.0.0	16,382 (2^{14} - 2)	65,534 (2^{16} - 2)
C	192 - 223	1 1 0	N.N.N.H	255.255.255.0	2,097,150 (2^{21} - 2)	254 (2^8 - 2)
D	224 -	1 1 1 0	Reserved for Multicasting			

	239		
E	240 - 254	1 1 1 1 0	Experimental, used for research

* Class A address 127 cannot be used and is reserved for loopback and diagnostic functions

Step 2 - Basic IP Addressing.

Task: Use the IP address chart and your knowledge of IP address classes to answer the following questions.

1. What is the decimal and binary range of the first octet of all possible class "B" IP addresses?
2. Decimal: From: ________ To: ________
3. Binary: From: ________ To: ________
4. Which octet(s) represent the network portion of a class C IP address? ______________
5. Which octet(s) represent the host portion of a class A IP address? ________________

Step 3 - Determine the host and network portion of the IP address.

Task: With the following IP host addresses, indicate the Class of each address, the Network Address or ID, the Host portion, the Broadcast Address for this network, and the default Subnet Mask.
Explanation: The host portion will be all zeros for the network ID. Enter just the octets that make up the host. The host portion will be all ones for a broadcast. The network portion of the address will be all ones for the subnet mask.

1. Fill in the following table:

Host IP Address	Addr. Class	Network Address	Host Address	Network Broadcast Address	Default Subnet Mask
216.14.55.137					
123.1.1.15					
150.127.221.244					
194.125.35.199					
175.12.239.244					

2. Given an IP address of 142.226.0.15
   a. What is the binary equivalent of the second octet? ___________________
   b. What is the Class of the address? _________________________________
   c. What is the network address of this IP address? ____________________
   d. Is this a valid IP host address (Y/N) ? ____________________________
   e. Why or why not?

____

____

____

3. Which is the maximum number of hosts you can have with a class C network address? _______
4. How many class B networks are there? ______________
5. How many hosts can each class B network have ? _______________
6. How many octets are there in an IP address? _________
7. How many bits per octet? _________

Step 4 - Determine which IP host addresses are valid for commercial networks.

Task: For the following IP host addresses determine which are valid for commercial networks. Why or why not?
Explanation: Valid means it could be assigned to a workstation, server, printer, router interface, and so on.

1. Fill in the following table.

IP Address	Valid Address? (Yes/No)	Why or why not?
150.100.255.255		
175.100.255.18		
195.234.253.0		
100.0.0.23		
188.258.221.176		
127.34.25.189		
224.156.217.73		

Lab 10.6.6 Subnet Mask 1

Estimated time: 45 min.

Objectives:

This lab will focus on Class C subnet masks and your ability to accomplish the following tasks:

- Cite some reasons why a subnet mask would be needed
- Distinguish between a Default Subnet Mask and a Custom Subnet Mask
- Determine the subnets available with a particular IP network address and subnet mask
- Given a network address and requirements for how many subnets and hosts, be able to determine what subnet mask should be used
- Given a network address and a subnet mask, be able to determine the number of subnets and host per subnet that can be created as well as useable subnets and useable number of hosts
- Use the "ANDing" process to determine if a destination IP address is Local or Remote
- Identify valid and invalid IP host address based on a given a Network number and subnet mask

Background:

This lab will help you understand the basics of IP subnet masks and their use with TCP/IP networks. The subnet mask can be used to split up an existing network into "subnetworks" or "subnets". This may be done to 1) reduce the size of the broadcast domains (create smaller networks with less traffic), 2) to allow LANs in different geographical locations to communicate or 3) for security reasons to separate one LAN from another. Routers separate subnets and the router determines when a packet can go from one subnet to another. Each router a packet goes through is considered a "hop". Subnet masks help workstations, servers and routers in an IP network determine if the destination host for the packet they the want to send is on their own network or another network. Default subnet masks were discussed in a prior lab. This Lab will review the Default Subnet Mask and then focus on Custom Subnet Masks which will use more bits than the default subnet mask by "borrowing" these bits from the host portion of the IP address. This creates a three-part address; 1) The original network address assigned, 2) The subnet address made up of the bits borrowed and 3) the host address made up of the bits left after borrowing some for subnets.

Tools / Preparation:

This is primarily a written lab exercise but you may want to use Control Panel / Network to review some real network IP addresses. The following resources will be required.

- PC workstation with Windows operating system (Win 95, 98, NT, or 2000) installed on the PC and access to the Windows Calculator.

Notes:

Step 1 - IP Address Basics.

Explanation: IP network addresses are assigned by the Internet Network Information Center (InterNIC). If your organization has a class "A" IP network address, the first octet (8 bits) is assigned be InterNIC and your organization can use the remaining 24 bits to define up to 16,777,214 hosts on your network. This is a lot of hosts. It is not possible to put all of these hosts on one physical network without separating them with routers and subnets. A workstation may be on one network or subnet and a server may be on another network or subnet. When the workstation needs to retrieve a file from the server it will need to use its subnet mask to determine the network or subnet that the server is on. The purpose of a subnet mask is to help hosts and routers determine the network location where a destination host can be found. Refer to the following table to review IP address classes, default subnet masks and the number of networks and hosts that can be created with each class of network address.

Cls	**1st Octet Decimal Range**	**1st Octet High Order Bits**	**Network / Host ID (N=Network, H=Host)**	**Default Subnet Mask**	**Number of Networks**	**Hosts per Network** (usable addresses)
A	1 - 126*	0	N.H.H.H	255.0.0.0	126 (2^7 - 2)	16,777,214 (2^{24} - 2)
B	128 - 191	1 0	N.N.H.H	255.255.0.0	16,382 (2^{14} - 2)	65,534 (2^{16} - 2)
C	192 - 223	1 1 0	N.N.N.H	255.255.255.0	2,097,150 (2^{21} - 2)	254 (2^8 - 2)
D	224 - 239	1 1 1 0	Reserved for Multicasting			
E	240 - 254	1 1 1 1 0	Experimental, used for research			

Step 2 - The "ANDing" process.

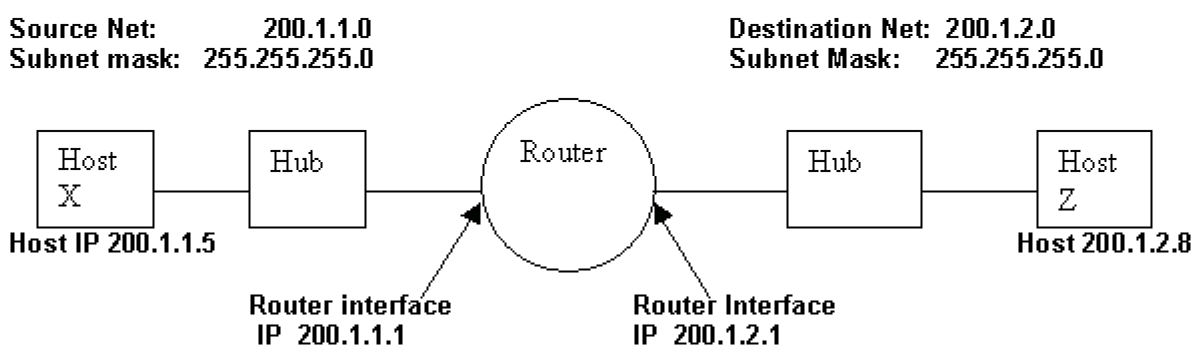
Explanation: Hosts and routers use the "ANDing" process to determine if a destination host is on the same network or not. The ANDing process is done each time a host wants to send a packet to another host on an IP network. If you want to connect to a server, you may know the IP address of the server you want to connect to or you may just enter the host name (for example, www.cisco.com) and a Domain Name Server (DNS) will convert the host name to an IP address. First the source host will compare (AND) its own IP address to its own subnet mask. The result of the ANDing is to identify the network where the source host resides. It will then compare the destination IP address to its own subnet mask. The result of the 2nd ANDing will be the network that the destination host is on. If the source network address and the destination network address are the same they can communicate directly. If the results are different then they are on

different networks or subnets and will need to communicate through routers or may not be able to communicate at all.

ANDing depends on the subnet mask. A default subnet mask for a Class C network is 255.255.255.0 or 11111111.111111111.111111111.00000000. This is compared to the source IP address bit for bit. The first bit of the IP address is compared to the first bit of the subnet mask and the second bit to the second, and so on. If the two bits are both ones, then the **ANDing result is a ONE**. If the two bits are a zero and a one or two zeros then the **ANDing result is a ZERO**. Basically this means that a combination of 2 ones results in a ONE, anything else is a zero. The result of the ANDing process is the network or subnet number that the source or destination address is on.

Step 3 - Two Class C networks using the default subnet mask.

Explanation: This example will show how a Class C default subnet mask can be used to determine which network a host is on. A default subnet mask does not break an address into subnets. If the default subnet mask is used then the network is not being "subnetted". Host X (source) on network 200.1.1.0 has an IP address of 200.1.1.5 and wants to send a packet to host Z (destination) on network 200.1.2.0 and has an IP address of 200.1.2.8. All hosts on each network are connected to hubs or switches and then to a router. Remember that with a Class C network address ARIN (American Registry for Internet Numbers) assigns the first 3 octets (24 bits) as the network address so these are two different class C networks. This leaves one octet (8 bits) for hosts so each class C network could have up to 254 hosts (2^8 power = 256 -- 2 = 254).



The ANDing process will help the packet get from host 200.1.1.5 on network 200.1.1.0 to host 200.1.2.8 on network 200.1.2.0 using the following steps.

a. **Host X compares its own IP address to its own subnet mask using the ANDing process**

Host X IP address 200.1.1.5	11001000.00000001.00000001.00000101
Subnet Mask 255.255.255.0	11111111.11111111.11111111.00000000
ANDing Result (200.1.1.0)	11001000.00000001.00000001.00000000

NOTE:
The result of step 3a of the ANDing process is the network address of host X which is 200.1.1.0

c. **Next host X compares the IP address of the Host Z destination to its own subnet mask using the ANDing process.**

Host Z IP address 200.1.2.8	11001000.00000001.00000010.00001000
Subnet Mask 255.255.255.0	11111111.11111111.11111111.00000000
ANDing Result (200.1.2.0)	11001000.00000001.00000010.00000000

NOTE:
The result of step 3b ANDing process is the network address of host Z which is 200.1.2.0.

e. Host X compares the ANDing results from step A and the ANDing result from step B and they are different. Host X now knows that host Z is not in its Local Area Network (LAN) and it must send the packet to its "Default Gateway" which is the IP address of the router interface of 200.1.1.1 on network 200.1.1.0. The router will then repeat the ANDing process to determine which router interface to send the packet out.

Step 4 - One Class C network using a Custom subnet mask.

Explanation: This example uses a single Class C network address (200.1.1.0) and will show how a class C custom subnet mask can be used to determine which subnetwork (or subnet) a host is on and to route packets from one subnetwork to another. Remember that with a class C network address ARIN assigns the first 3 octets (24 bits) as the network address. This leaves 8 bits (one octet) for hosts so each class C network could have up to 254 hosts (2^8 power = 256 -- 2 = 254).

Perhaps you want less than 254 host (workstations and servers) all on one network and you want to create 2 sub-networks and separate them with a router for security reason or to reduce traffic. This will create smaller independent broadcast domains and can improve network performance and increase security since these subnetworks will be separated by a router. Assume you will need at least 2 subnetworks and at least 50 hosts per subnetwork. Since you only have one Class C network address you have only 8 bits in the fourth octet available for a total of 254 possible hosts, you must create a Custom Subnet mask. You will use the custom subnet mask to "BORROW" bits from the host portion of the address. The following steps will help accomplish this:

a. The first step to "subnetting" is to determine how many subnets are needed. In this case you will need 2 subnetworks. To see how many bits you should borrow from the host portion of the network address, add the bit values from right to left until the total (decimal value) is greater than the number of subnets you will need. Since we need 2 subnets, add the one bit and the two bit which equals three. This is over the number of subnets we need, so we will need to borrow at least two bits from the host address starting from the left side of the octet that contains the host address.

Network address: 200.1.1.0

4th octet Host address bits:	1	1	1	1	1	1	1	1
Host address bit values (from right)	128	64	32	16	8	4	**2**	**1**

b. (Add bits starting from the right side (the 1 and the 2) until you get more than the number of subnets needed)

c. Once we know how many bits to borrow we take them from the left side of the first octet of the host address. Every bit we borrow from the host leaves fewer bits for the hosts. Even though we increase the number of subnets, we decrease the number of hosts per subnet. Since we need to borrow 2 bits from the left side, we must show that new value in our subnet mask. Our existing default subnet mask was 255.255.255.0 and our new "Custom" subnet mask is 255.255.255.192. The 192 comes from the value of the first two bits from the left (128 + 64 = 192). These bits now become 1s and are part of the overall subnet mask. This leaves 6 bits for host IP addresses or 2^6 = 64 hosts per subnet.

4th Octet borrowed bits for subnet:	**1**	**1**	1	1	1	1	1	1
Subnet bit values: (from left side)	128	64	32	16	8	4	2	1

d. With this information you can build the following table. The first two bits are the Subnet binary value. The last 6 bits are the host bits. By borrowing 2 bits from the 8 bits of the host address you can create 4 subnets with 64 hosts each. The 4 networks created are the "0" net, the "64" net, the "128" net and the "192" net. The "0" net and the "192" net are considered unusable. This is because the "0" net has all zeros in the subnet portion of the address and the 192 net has all ones in the subnet portion of the address.

Subnet No.	Subnet bits borrowed Binary value	Subnet bits Decimal Value	Host bits possible binary values (range) (6 bits)	Subnet / Host Decimal range	Useable?
Subnet #0	00	0	000000 - 111111	0 - 63	NO
Subnet #1	01		64 000000 - 111111	64 - 127	YES
Subnet #2	10		128 000000 - 111111	128 - 191	YES
Subnet #3	11		192 000000 - 111111	192 - 254	NO

e. Notice that the first subnet always starts at 0 and, in this case, increases by 64 which is the number of hosts on each subnet. One way to determine the number of hosts on each subnet or the start of each

subnet is to take the remaining host bits to the power of 2. Since we borrowed two of the 8 bits for subnets and have six bits left, the number of hosts per subnet is 2^6 or 64. Another way to figure the number of host per subnet or the "increment" from one subnet to the next is to subtract the subnet mask value in decimal (192 in the fourth octet) from 256 (which is maximum number of possible combinations of 8 bits) which equals 64. This means you start at 0 for the first network and add 64 for each additional subnetwork. If we take the second subnet (the 64 net) as an example the IP address of 200.1.1.64 cannot be used for a host ID because it is the "network ID" of the "64" subnet (host portion is all zeros) and the IP address of 200.1.1.127 cannot be used because it is the broadcast address for the 64 net (host portion is all ones).

Step 5 - One Class C network using a Custom Subnet Mask.

Task: Use the following information and the previous examples to answer the following subnet related questions.
Explanation: Your company has applied for and received a Class C network address of 197.15.22.0. You want to subdivide your physical network into 4 subnets, which will be interconnected by routers. You will need at least 25 hosts per subnet. You will need to use a Class C custom subnet mask and will have a router between the subnets to route packet from one subnet to another. Determine the number of bits you will need to borrow from the host portion of the network address and then the number of bits left for host addresses. (Hint: There will be 8 subnets)

1. Fill in the table below and answer the following questions:

Subnet No.	Subnet bits borrowed Binary value	Subnet bits Decimal & Subnet No.	Host bits possible binary values (range) (6 bits)	Subnet / Host Decimal range	Use?
Subnet #0					
Subnet #1					
Subnet #2					
Subnet #3					
Subnet #4					
Subnet #5					
Subnet #6					
Subnet #7					

2. **Notes:**
3. ____
4. ____
5. ____
6. **QUESTIONS: Use the table you just developed above to help answer the following questions:**
7. Which octet(s) represent the network portion of a Class C IP address?

____

8. Which octet(s) represent the host portion of a Class C IP address?

9. What is the binary equivalent of the Class C network address in the scenario (**197.15.22.0**)?
   Decimal Network address: __________ . __________ . __________ . __________
   Binary Network address: __________ . __________ . __________ . __________
10. How many high-order bits were borrowed from the host bits in the fourth octet?
11. What subnet mask must you use (show the subnet mask in decimal and binary)?
    Decimal Subnet mask: __________ . __________ . __________ . __________
    Binary subnet mask: __________ . __________ . __________ . __________
12. What is the maximum number of subnets that can be created with this subnet mask?
13. What is the maximum number of useable subnets that can be created with this mask?
14. How many bits were left in the 4th octet for host IDs ?
15. How many hosts per subnet can be defined with this subnet mask?
16. What is the maximum number of hosts that can be defined for all subnets with this scenario (assuming you cannot use the lowest and highest subnet numbers and cannot use the lowest and highest host ID on each subnet)?
17. Is **197.15.22.63** a valid host IP address with this scenario?
18. Why or why not ?

19. Is **197.15.22.160** a valid host IP address with this scenario?

____

20. Why or why not?

____

21. Host "A" has an IP address of **197.15.22.126**. Host "B" has an IP address of **197.15.22.129**. Are these hosts on the same subnet?

____

22. Why?

____

Lab 10.7.5 Subnetmask

Estimated time: 45 min.

Objectives:

This lab will focus on your ability to accomplish the following tasks:

- Work with Class B network addresses and subnets
- Determine the subnets available with a particular IP network address and subnet mask
- Given a network address and requirements, be able to determine how many subnets and hosts
- Be able to determine what subnet mask should be used to give the appropriate number of hosts and subnets
- Assign IP addresses and subnet masks to hosts and router interfaces
- Use the "ANDing" process to track an IP packet from a local host to a remote host through a router

Background:

This lab will focus on a Class B network with three subnets and using a subnet mask.

Tools / Preparation:

This is primarily a written lab exercise but you will want to use Control Panel / Network to review some real network IP addresses and the basics covered in Lab 10.4.1. The following resources will be required:

- PC workstation with Windows operating system (Win 95, 98, NT, or 2000) installed on PC to the Windows Calculator.

Notes:

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Step 1 - IP Address Basics

Explanation: For reference, the IP addressing table is included here. IP network addresses are assigned by ARIN. You will work with a Class B.

Cls	1st Octet Decimal Range	1st Octet High Order Bits	Network / Host ID (N=Network, H=Host)	Default Subnet Mask	Number of Networks	Hosts per Network (usable addresses)

A	1 - 126*	0	N.H.H.H	255.0.0.0	126 (2^7 - 2)	16,777,214 (2^{24} - 2)
B	128 - 191	1 0	N.N.H.H	255.255.0.0	16,382 (2^{14} - 2)	65,534 (2^{16} - 2)
C	192 - 223	1 1 0	N.N.N.H	255.255.255.0	2,097,150 (2^{21} - 2)	254 (2^8 - 2)
D	224 - 239	1 1 1 0	Reserved for Multicasting			
E	240 - 254	1 1 1 1 0	Experimental, used for research			

Step 2 - Class B network address with 3 subnets.

Task: Use the information below and from prior labs to help determine your valid subnets and host IP addresses. Answer the following questions.
Explanation: Your institution has a Class B network address of 150.193.0.0. This class B network address will be subdivided to accommodate your physical network and you will need at least 50 subnets interconnected with routers. Each subnet needs to be able to handle at least 750 hosts per subnet (workstations, servers and router interfaces). As the network manager for your local campus at the institution, you were given the first 10 of these subnets for use with your local campus. You will be using 6 of these subnets now and will keep the others for future growth. Do **NOT** use the first or last subnet.

1. What is the binary equivalent of the Class B network address 150.193.0.0 in the exercise?
   ________ . __________ . __________ . ___________
2. Which octet(s) and how many bits are used to represent the network portion of this network address?

   ____

3. Which octet(s) and how many bits represent the host portion of this Class B network address?

   ____

4. How many original Class B networks are there?

   ____

5. What is the total number of hosts that can be created with a Class B network address if it has not been subdivided?

   ____

6. How many bits must you borrow from the host portion of the network address in order to provide at least 50 subnets and at least 750 hosts per subnet?

   ____

7. What will the Subnet Mask be (using dotted decimal notation) based on the number of bits borrowed in step 6?

____

8. What is the binary equivalent of the subnet mask above:

________ . ________ . ________ . ________

Step 3 - Class B network address with 3 subnets.

Task: Complete the table below according to the instructions. Use the information in the table to answer the questions and complete the diagram at the end of this lab.
Explanation: Be sure to specify all four octets for the subnet address and subnet mask. The same subnet mask should be used for all hosts, router interfaces and all subnets. Having a common subnet mask will allow hosts and routers to determine which subnet the IP packet is intended for. Router interfaces will usually be numbered first when assigning IP addresses and hosts will receive higher numbers.

1. Fill in the following table for each of the possible subnets that can be created by borrowing 6 bits for subnets from the third octet (1st host octet). Identify the Network Address, the Subnet Mask, the Subnetwork Address, the range of possible host IP addresses for each subnet, the broadcast address of each subnet and also indicate whether the subnet is useable or not. You will only use 3 of these subnets for the exercise.

SN#	Network Address	Subnet mask	Subnetwork Address	Range of possible Host IP Addresses	Broadcast Address	Use?
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						

2. Assign an IP Address and Subnet Mask to router interface A and write it down here.

____

____

3. Assign an IP Address and Subnet Mask to router interface B and write it down here.

____

____

4. Assign an IP Address and Subnet Mask to router interface C and write it down here.

____

____

5. Assign a host IP Address to Host X on Subnet A and assign an IP address to Host Z on Subnet C (answers may vary). Describe the steps (using ANDing) for the process of sending an IP packet from Host X to Host Z through the router. Remember, when ANDing two 1s together the result is a 1, ANDing any other combination (1 and 0, 0 and 1 or 0 and 0) results in a zero (0). Also, when ANDing two network IP addresses together the result of the ANDing process will be the network (or subnetwork) address of the destination IP address in the packet. Use the information from the diagram above to help assign IP addresses and subnet masks.

____

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____

____

6. What is the result of the ANDing process for Host X?
   Decimal Host X IP addr: ______ . ______ . ______ . _______
   Binary Host X IP addr: ______ . ______ . _______ . _______
   Binary Subnet Mask: ______ . _____ . _______ . ________
   Binary ANDing Result: _______ . _______ . _______ . ________
7. **Decimal ANDing Result:** ______ . ______ . _______ . ________
8. What is the result of the ANDing process for Host Z?
   Decimal Host Z IP addr: ____ . _____ . _______ . ______
   Binary Host Z IP addr: ______ . _____ . _______ . _______
   Binary Subnet Mask: _____ . ______ . ______ . _______
   Binary ANDing Result: ______ . ______ . _______ . _______
   Decimal ANDing Result: _____ . _____ . ______ . ______
9. The Decimal ANDing result from questions 7 is the network/subnet that Host X is on. The result from question 8 is the network/subnet that Host Z is on. Are Host X and Host Z on the same network/subnet?

____

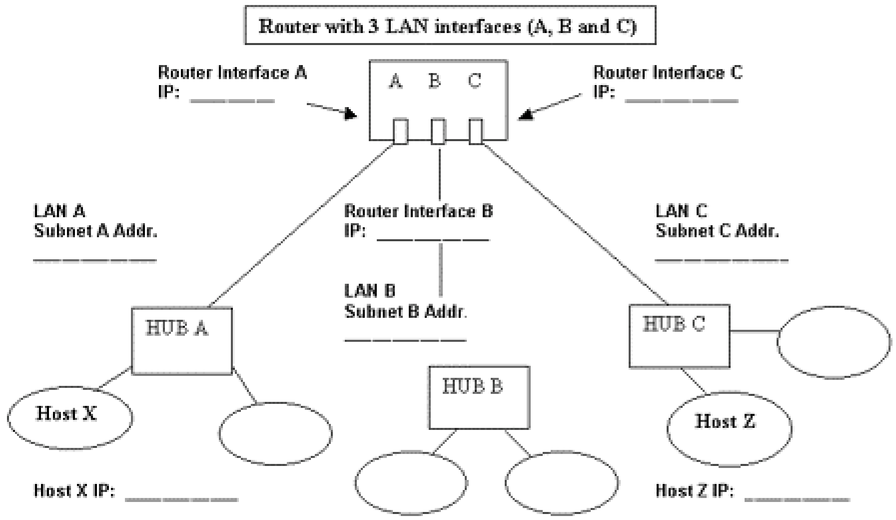
____

10. What will Host X now do with the packet?

____

____

11. Fill in the blanks in the following diagram with the correct Network and IP addresses.



Lab 10.7.7 Subnet Mask

Estimated time: 45 min.

Objectives:

This lab will focus on your ability to accomplish the following tasks:

- Work with a more complex Class C subnet scenario
- Determine the subnets available with a particular IP network address and subnet mask
- Given a network address and requirements, be able to determine how many subnets and hosts
- Be able to determine what subnet mask should be used to give the appropriate number of hosts and subnets
- Assign IP addresses and subnet masks to hosts and router interfaces
- Use the "ANDing" process to move an IP packet from a local host to a remote host through a router

Background:

This lab will build on Lab Subnet Mask 1 and help develop a better understanding of IP subnet masks using a real-world example with additional worksheet exercises based on foundations established in the prior lab. This lab will focus on a Class C network with three subnets and using a Custom Subnet Mask.

Tools / Preparation:

This is primarily a written lab exercise but you will want to use Control Panel / Network to review some real network IP addresses and the basics covered in the prior lab. The following resources will be required:

- PC workstation with Windows operating system (Win 95, 98, NT, or 2000) installed on the PC and access to the Windows Calculator.

Notes:

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Step 1 - IP Address Basics

Explanation: For reference, the IP addressing table from the prior lab is included here. IP network addresses are assigned by the Internet Network Information Center (InterNIC). You will work with a Class C.

Cls	1st Octet	1st	Network /	Default	Number	Hosts per

	Decimal Range	Octet High Order Bits	Host ID (N=Network, H=Host)	Subnet Mask	of Networks	Network (usable addresses)
A	1 - 126*	0	N.H.H.H	255.0.0.0	126 (2^7 - 2)	16,777,214 (2^{24} - 2)
B	128 - 191	1 0	N.N.H.H	255.255.0.0	16,382 (2^{14} - 2)	65,534 (2^{16} - 2)
C	192 - 223	1 1 0	N.N.N.H	255.255.255.0	2,097,150 (2^{21} - 2)	254 (2^8 - 2)
D	224 - 239	1 1 1 0	Reserved for Multicasting			
E	240 - 254	1 1 1 1 0	Experimental, used for research			

Step 2 - Class C network address with three subnets.

Task: Use the following information and use the information from the worksheet in the prior lab to help determine your valid subnets and host IP addresses. Do **NOT** use the zero or last subnet.
Explanation: Your company has a class C network address of 200.10.57.0. You want to subdivide your physical network into three subnets (A, B and C) using a router as shown in the diagram at the end of the worksheet. You will need at least 20 hosts per subnet. Answer the following questions.

1. What is the binary equivalent of the Class C network address **200.10.57.0** in the exercise?
   __________ . __________ . __________ . __________
2. Which octet(s) represent the network portion and which octet(s) represent the host portion of this Class C network address?

   ____

3. How many bits must you borrow from the host portion of the network address in order to provide at least three subnets and at least 20 hosts per subnet?

   ____

4. What will the Subnet Mask be (using dotted decimal notation) based on the number of bits borrowed in step 3? _________ . _________ . __________ . __________
5. What is the binary equivalent of the subnet mask above:
   _________ . _________ . __________ . __________

Step 3 - Class C network address with three subnets.

Task: Complete the table below according to the instructions. Use the information in the table to answer the questions and complete the diagram at the end of this lab.
Explanation: Be sure to specify all four octets for subnet address and subnet mask. The same subnet mask should be used for all hosts, router interfaces and all subnets. Having a common subnet mask will allow hosts and routers to

determine which subnet the IP packet is intended for. Router interfaces will usually be numbered first when assigning IP addresses and hosts will receive higher numbers.

1. Fill in the following table for each of the possible subnets that can be created by borrowing three bits for subnets from the fourth octet (host octet). Identify the Network Address, the Subnet Mask, the Subnetwork Address, the range of possible host IP addresses for each subnet, the broadcast address of each subnet and also indicate whether the subnet is useable or not. You will only use three of these subnets for the exercise.

SN#	Network Address	Subnet mask	Subnetwork Address	Range of possible Host IP Addresses	Broadcast Address	Use?
1st						
2nd						
3rd						
4th						
5th						
6th						
7th						
8th						

2. Assign an IP Address and Subnet Mask to router interface A and write it down here.
   ___________________ / ____________________
3. Assign an IP Address and Subnet Mask to router interface B and write it down here.
   ___________________ / ____________________
4. Assign an IP Address and Subnet Mask to router interface C and write it down here.
   ___________________ / ____________________
5. Assign a host IP Address to Host X on Subnet A and assign an IP address to Host Z on Subnet C (answers may vary). Describe the steps (using ANDing) for the process of sending an IP packet from Host X to host Z through the router. Remember, when ANDing, two 1s together the result is a 1, ANDing any other combination (1 and 0, 0 and 1, or 0 and 0) results in a Zero (0). Also, when ANDing two network IP addresses together the result of the ANDing process will be the network (or subnetwork) address of the destination IP address in the packet. Use the information from the diagram above and prior lab to help assign IP addresses and subnet masks.

   ____

   ____

   ____

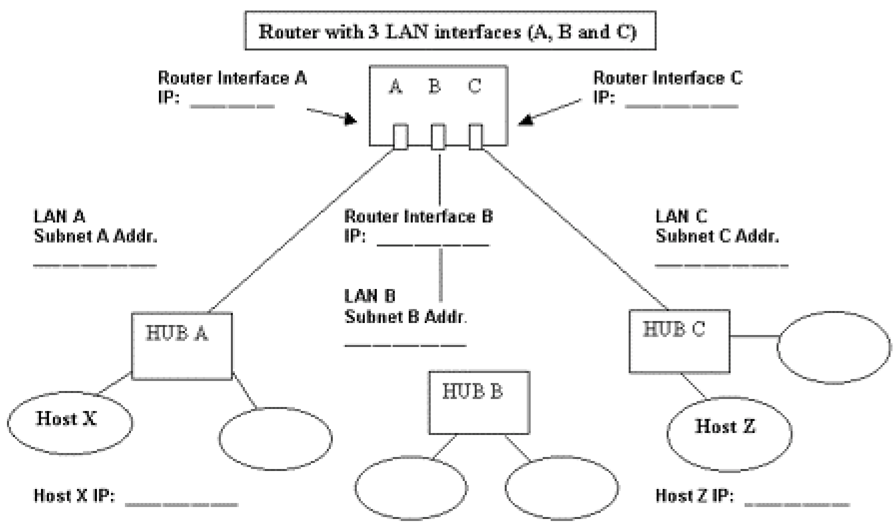
6. What is the result of the ANDing process for Host X?
Decimal Host X IP addr: _______ . _______ . ________ . ________
Binary Host X IP addr: _______ . _______ . ________ . ________
Binary Subnet Mask: _______. _______ . ________ . ________
Binary ANDing Result: _______ . _______ . ________ . ________
Decimal ANDing Result: ________ . ________ . ________ . ________
7. What is the result of the ANDing process for Host Z?
Decimal Host Z IP addr: ________ . ________ . ________ . ________
Binary Host Z IP addr: ________ . ________ . ________ . _________
Binary Subnet Mask: ________ . ________ . _________ . _________
Binary ANDing Result: ________ . ________ . ________ . _________
Decimal ANDing Result: ________ . ________ . ________ . _________
8. The Decimal ANDing result from questions 6 is the network/subnet that Host X is on. The result from question 7 is the network/subnet that Host Z is on. Are Host X and Host Z on the same network/subnet?

____

9. What will Host X now do with the packet?

____

10. Fill in the blanks in the following diagram with the correct Network and IP addresses.



Lab 11.9.1 Protocol Inspector and ARP

Estimated time: 20 min.

Objectives:

- Use Protocol Inspector (or equivalent) Software to study ARP requests and replies.

Background:

Protocol analysis software has a feature called capture. This feature allows all frames that travel through an interface to be captured for analysis. With this feature, you can peek in on the Address Resolution Protocol process. You may have found ARP a bit abstract, but with the protocol analyzer we can see just how important ARP is to the normal functioning of a network.

Tools / Preparation:

Each PC must be running Windows 95, 98, or NT, Microsoft TCP/IP stack, and Winsock 2.0. Fluke Protocol Inspector 3.0 (or equivalent) must be installed on each PC. During the installation of the software you must specify which network adapter (NIC, dialup, and so on) you wish to monitor. That is, specify the NIC which attaches the PCs to an Ethernet. The PCs should be on either a 10BASE-T or 100BASE-TX Ethernet network which preferably includes servers, switches, routers, printers, and a connection to a web server, or preferably the Internet (this will make the protocol analysis more interesting).

Worksheet

1. Open Protocol Inspector (or equivalent) software.

   ____

2. Go to detail view. What do you see?

   ____

3. Start a capture. What happens?

   ____

4. Open an MS-DOS window.

   ____

5. Using arp ---a examine contents of ARP table. What do you see?

   ____

6. Using arp ---d a.b.c.d delete all entries in ARP table. Use arp ---a to re-examine the arp table. What has happened?

____

7. Using ping a.b.c.d to trigger an ARP frame. What happens? Ping your own machine or another machine on the network.

____

8. Stop the capture. What happens?

____

9. Study the ARP frames, ping frames, and statistics using various views, especially the detail view. Describe the various views and what you learned about ARP.

____

10. Start another capture to examine the network you are on.

____

11. Use the network for a minute or so (sending emails, request web pages, and so on) over some period of time (say 2 minutes) and see, in detail how many ARP frames occur. Are any occurring? If so, why?

____

____

____

Reflection:

Why is ARP necessary for LANs to function?

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Lab 12.1.3 Protocol Inspector and TCP

Estimated time: 30 min.

Objectives:

- Use Protocol Inspector (or equivalent) software to view dynamic TCP operations

Background:

Protocol analysis software has a feature called capture. This feature allows all frames, through an interface, to be captured for analysis. With this feature, you can see how the Transmission Control Protocol (TCP) moves segments filled with user data across the network. You may have found TCP to be a bit abstract, but with the protocol analyzer we can see just how important TCP is to network processes (such as email and web-browsing).

Tools / Preparation:

Each PC must be running Windows 95, 98, or NT, Microsoft TCP/IP stack, and Winsock 2.0. Fluke Protocol Inspector ver. 3.0 (or higher) Software (Check the Web for downloadable upgrades) must be installed on each PC. During the installation of the software you must specify which network adapter (NIC, dialup, and so on) you wish to monitor. Then, specify the NIC that attaches the PCs to an Ethernet. The PCs should be on either a 10BASE-T or 100BASE-TX Ethernet network. Preferably, the network includes servers, switches, routers, printers, and a connection to a web server, or preferably the Internet (this will make the protocol analysis more interesting). The following resources will be required:

- PC with Windows 95, 98, or NT, Microsoft TCP/IP stack, and Winsock 2.0.
- Fluke Protocol Inspector ver. 3.0 (or higher) Software (Check the Web for downloadable upgrades)
- Browser and email applications installed and running

Worksheet

1. Open Protocol Inspector and your browser.
2. Go to detail view.
3. Start a capture.
4. Request a Web Page.
5. Watch the monitor view while the web page is requested and delivered.
6. Stop the capture.
7. Study the TCP frames, HTTP frames, and statistics using various views, especially the detail view.
8. Using the detail view, explain what evidence it provides about a) TCP handshakes b) TCP acknowledgments c) TCP segmentation and segment size d) TCP sequence numbers and e) TCP sliding windows.

Reflection:

Did this lab help you to visualize the TCP protocol in action? Why or why not?

